10-2019

Ensuring Economic Viability and Sustainability of Coffee Production

Jeffrey D. Sachs
Columbia University, The Center for Sustainable Development, sachs@columbia.edu

Kaitlin Y. Cordes
Columbia Law School, Columbia Center on Sustainable Development, kaitlin.cordes@law.columbia.edu

James Rising
London School of Economics and Political Science, J.A.Rising@lse.ac.uk

Perrine Toledano
Columbia Law School, Columbia Center on Sustainable Investment, ptoled@law.columbia.edu

Nicolas Maennling
Columbia Law School, Columbia Center on Sustainable Investment, nmaenn@law.columbia.edu

Ensuring Economic Viability & Sustainability of Coffee Production

October 2019

Jeffrey Sachs, Kaitlin Y. Cordes, James Rising, Perrine Toledano, and Nicolas Maennling

Columbia Center on Sustainable Investment
A JOINT CENTER OF COLUMBIA LAW SCHOOL AND THE EARTH INSTITUTE, COLUMBIA UNIVERSITY

Photo by Mike Kenneally on Unsplash

Acknowledgements and Methodology

This report was authored by Jeffrey Sachs (Columbia University and UN Sustainable Development Solutions Network), Kaitlin Y. Cordes (Columbia Center on Sustainable Investment (CCSI)), James Rising (London School of Economics), Perrine Toledano (CCSI), and Nicolas Maennling (CCSI).

The report was sponsored by the Colombian Coffee Growers Federation (Federación Nacional de Cafeteros de Colombia - FNC), the Agence des Cafes Robusta d'Afrique et de Madagascar (ACRAM), African Fine Coffees Association (AFCA), the Inter-American Development Bank (IDB), the International Coffee Organization (ICO), Promecafe, and the Secretary of Agriculture and Rural Development in Mexico (SAGARPA). Additional work, particularly to develop the simulation model and corresponding climate scenarios, was funded separately by Lavazza. Any views expressed are the authors'.

The report was commissioned by the World Coffee Producers Forum, under the coordination of the Colombian Coffee Federation, Inc – New York (North America Subsidiary of the Colombian Coffee Growers Federation - FNC). We deeply appreciate the leadership and commitment of Mr. Juan Esteban Orduz and Juan José Mesa.

The authors are grateful for the excellent research support and assistance we received. We are particularly grateful to Margaret Sagan and Ikbal Ben Gaied Hassine for their dedication to this project. We also extend deep thanks to Melissa Au, Louis Bourgeois, Michelle Chan, Mateusz Kasprowicz, Varistha Nakornthap, Senthil Nathan, Giovanni Perez, Gloria Zhao Gao, and Mahathi Aguvaveedi. In addition, we thank Lisa Sachs for her coordination and support of the project; Solina Kennedy for her invaluable editing, research, and other support; Sam Szoke-Burke for his supervision of research, editing, and additional support on the project; Ella Merrill and Jesse Coleman for their edits; and Carolina Ocampo-Maya for her valuable insights.

We appreciate the many people who took time to speak with us, and owe particular debts of gratitude to the following: Christian Bunn (CIAT); Mario Cerutti (Lavazza); Carl Cervone and Diana Baquero (Enveritas); Janina Grabs (University of Münster, Germany); Ric Rhinehart (Specialty Coffee Association's Coffee Price Crisis Response Initiative); Michael Sheridan (Intelligentsia); Jose Sette, Christoph Saenger, and Marcela Umana (ICO). We also thank Roxann Henry, Tom McQuail, David Meyer, and Aniek Schadd of Morrison Foerster, and A4ID for connecting us to them.

We are extremely grateful to the producers and other stakeholders who provided direct feedback at the World Coffee Producers Forum meeting in July 2019, including the more than 100 participants in a workshop dedicated to discussing some of the ideas presented herein.

For this report, we developed a new economic model of supply and demand in the coffee sector, which forms the core of our quantitative analysis. The model simulates a global price equilibrium between 136 consuming countries and the farming decisions in 3024 coffee-growing regions. Our report is also grounded in extensive desk research and at least 72 interviews with 86 people, representing producers, small and large companies, civil society organizations and multi-stakeholder platforms, research institutions and academics, and others. It has also been strengthened by feedback we have received through other channels, including via email and particularly in response to public presentations at events organized by the ICO and the European Coffee Federation in June 2019 and by the World Coffee Producers Forum in July 2019.

The report was originally written in English.

We very much welcome feedback on the ideas presented herein. This report is part of an ongoing and evolving analysis of how to achieve sustainability in the coffee sector, and we look forward to continuing to build our analysis in partnership with producers, industry actors, and the many other stakeholders focused on making coffee sustainable.

Suggested Citation

Jeffrey Sachs, Kaitlin Y. Cordes, James Rising, Perrine Toledano, and Nicolas Maennling, "Ensuring Economic Viability and Sustainability of Coffee Production," Columbia Center on Sustainable Investment (October 2019).

Photo by Rodrigo Flores on Unsplash

Executive Summary

Coffee is the world's favorite beverage, with an estimated 400 billion cups consumed per year. Coffee provides livelihoods for at least 60 million people, across dozens of countries. Coffee is healthful and protective against many chronic diseases. For these and other reasons, promoting the long-term health, wellbeing, and environmental sustainability of the much beloved coffee sector should be a clear priority.

Yet coffee is experiencing a sustainability crisis, stemming from unsustainable economic, social, and environmental aspects of coffee production. The recent decline in world coffee prices has further squeezed coffee producers, and thrown a tremendous number of producers below the global extreme poverty line of US$1.90 per day. While many consumers willingly pay high prices for coffee, coffee farmers receive a tiny fraction of that retail price. At these low farmgate prices, coffee production is not economically viable for a significant number, perhaps a majority, of coffee farmers.

The sustained low prices hurt even more as coffee producers begin to bear the brunt of climate change and variability. Climate change is expected to undermine the suitability of coffee across large regions, to decrease coffee bean quality, and to increase the risk of coffee diseases. The coffee industry as a whole has an interest in ensuring that coffee production can adapt to climate change, yet it currently lacks effective industry-wide responses. For now, producers lose the most when climate-induced weather events and diseases wipe out crops or reduce their quality.

Although coffee producers shoulder the biggest risks of low prices and climate-induced events, farmworkers in the coffee industry can be even more vulnerable. In the worst cases, workers have been found in "conditions analogous to slavery"—even on certified farms. More generally, farmworkers on both non-certified and certified farms can be vulnerable to exploitation, and many are not paid the required minimum wage.

There are, of course, bright spots within the coffee sector. Highly efficient producers, especially in Brazil and Vietnam, for example, are able to make a profit even at today's low prices. Producers who grow high-quality coffee and who are able to access ethically-minded specialty roasters can command prices significantly above the quoted international price. Some producers have found ways to capture more of the final retail price, including through producer-owned businesses that sell directly to consumers. Yet, these remain bright spots juxtaposed against the grim reality faced by producers around the world.

Four years after the adoption of the Sustainable Development Goals (SDGs), and in the face of the ongoing price and climate crises, the coffee sector now stands at a crossroads. Will the coffee sector continue following a business-as-usual trajectory of limited and piecemeal sustainability endeavors, which would ultimately result in further concentration of coffee producers and heightened supply risks? Or will the coffee sector undertake strong concerted efforts to support a more sustainable and resilient future for producers and the sector overall?

Based on our research, we believe there is a clear opportunity for coffee sector actors to work together to achieve greater sustainability within coffee production and in coffee-growing regions. Below, we provide a brief summary of our findings and recommendations.

Photo by Isaac Benhesed on Unsplash

Coffee Sector Snapshot: Consolidation at Both Ends of the Value Chain

Beyond the collapse of the International Coffee Agreement's quota regime, the most fundamental reason for lower prices post-1990 appears to be the continued rise of productivity of Brazil and Vietnam. From the 3.7 million tons of coffee added to world production between 1995 and 2017, 83% came from Brazil and Vietnam. Yield rates have increased by over 100% in Vietnam and 30% in Brazil in that time period. Those increases contrast starkly with the relatively stable yields for most other coffee-producing countries.

Our model suggests that today's low prices are only moderately lower than the long-term equilibrium. Prices are further pushed down by a strong US Dollar, a weak Brazilian Real, and, potentially, the increased market power of buyers. While the financialization of the futures market may contribute to short-term price fluctuations, we do not believe that this phenomenon is the main driver for recent low prices.

Alongside low coffee prices, production costs for producers have also increased (particularly sharply since 2010), further squeezing incomes. These low prices and rising costs have increased the concentration of coffee producers. Under a business-as-usual pathway, this consolidation is likely to continue, resulting in less variety in origins, in tastes, and in quality, with a potential dampening effect on demand; lost smallholder knowledge; and heightened supply risks of large-scale disruptions and greater price volatility.

In stark contrast to the millions of coffee producers currently suffering an economic crisis, the roaster and retail sector is flourishing. Total coffee industry revenues are estimated at between $200-250 billion. The profitability of the coffee sector and its growth potential have led to consolidation. In the grocery market segment, brands are increasingly intertwined, and working to sell at higher premiums.

Brand market power and the resulting high margins of leading roasters and retailers have been driven in particular by increased value addition in importing countries, which comes through the development of lucrative "intangible" aspects of coffee. The evidence suggests that a rising share of total coffee-sector income is earned downstream, with enormous markups and returns for intangibles such as brand.

The starkly contrasting situations of profitable downstream actors and suffering upstream ones may lead an important segment of consumers to strongly question whether the brands they trust support producers' economic sustainability. This plausibly could shift some brand loyalty towards companies that are better partners for producers; it may also create an opportunity for producers to capture more of the final retail price through marketing directly to consumers.

Global Supply and Demand – Analytical Model

The world coffee price is determined by global supply and demand. To simplify the reasoning for ease of understanding, it is useful to divide the global supply for Arabica coffee into two parts, Brazil and the rest of the world (ROW). Brazil's coffee sector is composed of a low-productivity and non-mechanized subsector, and a high-productivity and mechanized subsector with a highly elastic supply curve when prices reach a certain level. This is because Brazil has millions of hectares of land that were previously cultivated for coffee production, but are not currently used for that purpose. This land could be returned to coffee production under the right price conditions.

Outside of Brazil, there is considerably less available land to bring into new coffee production and most coffee lands are in mountainous regions that are not suitable for mechanized harvesting. Production is labor intensive and yields are lower. ROW's supply curve is therefore inelastic and the main opportunity for increased production and profitability in ROW is related to higher yields and quality on existing coffee farms.

This analytical model allows us to ask and answer three important questions. First, what happens if ROW improves its coffee farming techniques? Output in the ROW rises, while production in high-yield Brazilian farms contracts by the same amount. The world price remains unchanged. Second, what happens if high-yield Brazil further improves its technologies? Production in high-yield Brazil expands, while production in ROW and in low-yield Brazil contracts, and world coffee consumption rises at a lower world price. A similar outcome occurs if the Brazilian Real experiences a real depreciation compared with the dollar and euro. Third, what happens if world demand increases? The increase in supply is met by high-productivity Brazilian coffee production with supply from low-tech ROW remaining unchanged.

We also revised the model to account for imperfect competition in the coffee industry: in particular, potential market power in the roast-retailer segment of the market, given the increasing consolidation of this segment. This is a valid concern, given increasing concentration in the roaster-retailer component of the market, as well as the increased intertwining of brands through various branding and sales agreements.

At the farm gate, the big difference between a competitive buyer and a monopsonistic buyer of coffee is that the monopsonistic buyer has the incentive and the ability to put downward pressure on the price paid to the producers. When a market faces a monopsonistic buyer, it may set a minimum price without endangering the quantity purchased. Since the monopsonist can no longer push the farmgate price lower, it would buy up the entire quantity available; doing so will still earn it a net profit.

Although there is probably little monopsonistic power vis-à-vis Brazil's high-tech producers given that their supply elasticity is quite high, it may be true that coffee producers in ROW are facing increased monopsonistic pressures. If these pressures exist, creating a minimum price linked to the Brazil high-tech farmgate price might be a workable and beneficial solution for ROW producers.

Global Supply and Demand – Empirical Model

To quantify the relationships illustrated in our analytical model and test for potential climate change impacts, we developed quantitative coffee supply and demand models. These are grounded on high-resolution data, account for regional differences, and are projected under climate change.

The empirical results are as follows:

- Under a business-as-usual scenario, by 2050, average warming in coffee producing regions will be 2.8 °C (up from 1.5 °C today), and the average temperatures in 90% of the tropics will exceed the current 1-in-100 year annual temperatures heat events.
- By 2050, we project 75% of suitable land for Arabica coffee production and 63% of land for Robusta coffee production to be lost. In 20 countries, including Honduras and India, the remaining suitable land will be less than the land currently under coffee cultivation.
- If prices remain unchanged, average yields are projected to decrease by 7% and planted area to be reduced by 13% by 2050. Total production of Arabica coffee declines by 10%, but production of Robusta coffee increases due to yield increases in Vietnam.
- Considerable yield gaps exist, and closing these would both increase total production and the share of the market held by countries other than Brazil and Vietnam. Improving agricultural practices and engaging in renovation and rehabilitation of coffee trees could increase global Arabica coffee production by 18% and Robusta coffee production by 16%.
- If coffee were to return to areas that it previously occupied, global production could increase by 60%.

Over the next decades, significant changes to coffee demand will also occur, driven by expanding consumption in emerging markets, the rise of capsule use, and continued activity in the specialty market. As a result, total consumption is expected to increase by 26% by 2030, under a business-as-usual scenario, with most of the demand increases coming from developing countries.

We do not expect a significant recovery of prices without intervention. Despite the combined effects of climate change and increased demand, the potential for low-cost production in Brazil is expected to prevent prices from rising more than $1/kg.

Without efforts to close yield gaps, 76% of the predicted increase in demand will be provided by Brazil and Vietnam, thereby further concentrating coffee production in these two countries and reducing variety in origins and quality.

Addressing Coffee Sustainability

Coffee's sustainability crisis has thrown into stark relief one indisputable fact: the current structure of the coffee industry is not working well for most producers. In light of this reality, we make several recommendations.

1. National Coffee Sustainability Plans

We suggest that each coffee-producing country develop a **National Coffee Sustainability Plan (NCSP),** that accounts for differentiated needs, challenges, and opportunities within the country's coffee sector. At their core, NCSPs would offer clear strategic plans for supporting producers, promoting sustainable coffee production, and aligning producing regions with the SDGs.

The design of NCSPs should be done through multi-stakeholder, participatory, inclusive, and transparent processes. We suggest that they could be prepared by multi-stakeholder **Country Coffee Platforms (CCPs)** in each coffee-producing country.

There is not a one-size-fits-all approach for NCSPs. However, each NCSP should include a focus on the following collective goods: (a) Developing and implementing comprehensive climate change adaptation strategies, including insurance options; (b) ensuring on-farm financing options at attractive rates for producers; (c) strengthening on-farm support to viable small- and medium-scale producers with a focus on increasing their profitability; (d) implementing other improvements to the enabling environment for farmers, such as formalizing and protecting land rights of small-scale producers; (e) supporting producers' market opportunities; (f) providing income support to the poorest farmers during periods of sustained low prices; (g) help support broader realization of the SDGs in coffee-growing regions; and (h) strengthening capacity to enforce compliance with labor laws, monitor deforestation and other environmental harms.

The activities to be undertaken under NCSPs should be designed and implemented using a gender-sensitive approach. Implementation and monitoring of many activities could also be facilitated through the use of mobile applications, new technologies, and other innovations.

2. A Global Coffee Fund Underpinned by a Multi-Stakeholder Approach

A **Global Coffee Fund (GCF)**, financed by the main coffee industry actors and used to leverage additional public sector funding, would enable stakeholders to implement activities under the NCSPs. The GCF would be a key *pre-competitive initiative* of the coffee sector to fill critical financing gaps for sustainability investments in coffee-producing regions. The GCF would multiply, at a far greater scale, the public-private efforts that have been undertaken by specific companies within their own coffee supply chains, and would ensure the necessary financing for more robust and comprehensive sustainability efforts. The pre-competitive industry funding would be complemented by: 1) increased funding by bilateral and multilateral donors, 2) increased commitments in the national budgets of coffee-growing nations, and 3) commercial investments by the private sector within their own value chains.

The GCF is not charity. Rather, it is an avenue for downstream and midstream actors such as roasters, retailers, and traders to fulfill their co-responsibility for achieving a sustainable coffee sector and to shoulder more of the risks that currently fall too heavily on producers alone.

The operations and governance of the Global Coffee Fund would integrate strong oversight through a multi-stakeholder Governing Board, local ownership of planning through the CCP, and independent expert support. Governance mechanisms would be designed to guard against corruption and fraud. To minimize redundancy and the need to develop entirely new bureaucracies, the GCF could potentially be hosted by one or more existing multi-stakeholder initiatives focused on coffee sustainability.

Our estimates suggest that the amount of money needed to make considerable progress on implementing activities under the NCSPs is in the region of US$10bn per year. We provisionally suggest a goal of raising $2.5bn per year through pre-competitive private sector contributions to the GCF. Using the 2018 global export number of 7.3bn kg of green coffee, this would amount to 34 cents per kg of green coffee contributed to the GCF, which is in the range of 0.25-0.50 cents per cup. In other words, the targeted level of funding would require no more than half a penny per cup sold.

Taken together, these various contributions would result in a 25% allocation of the overall funding goal for each main source of funds: the GCF, donors, producing-country governments, and competitive private sector investments. Such an approach would embody a public-private partnership grounded in equally shared responsibility between the public and the private sectors.

While these private sector and public sector funds would be roughly equal at the global level, money from the GCF would not have to be distributed in equal proportions for each participating country. Doing so would enable the GCF to support all coffee-producing countries, while also taking into consideration the country-specific needs and funding opportunities that each country has (e.g., government budgets, private sector competitive investments), as well as prioritizing the SDG gaps in the poorest places and for the poorest producers and workers.

The scale of contributions suggested for the GCF is much higher than the current sustainability spend within the coffee industry, yet it is entirely reasonable as a fraction of the overall value of the industry, particularly given the significant benefits that would accrue to coffee industry actors if a sustainable coffee future were realized. We suggest that the largest roasters, retailers, and traders should be both the forerunners in contributing to the fund, as well as the entities that contribute the most. These actors have outsized impacts on the industry, should have particularly strong interests in a sustainable coffee future, and proportionally have the largest responsibilities for ensuring the long-term sustainability of coffee value chains.

Taken together, the National Coffee Sustainability Plans and the Global Coffee Fund provide a means to implement the strategic locally owned actions within countries and the significant investments throughout the sector that are necessary for a sustainable coffee industry and thriving coffee producers.

3. Increasing Producer Profits

The coffee industry has changed significantly in recent years, which has created new challenges for many producers, but also opens up new opportunities. In particular, the high consolidation of the industry, and the mainstreaming of e-commerce technologies and mobile applications for farmers, provide unique conditions to depart from the traditional coffee business model that has become increasingly unsustainable for many coffee producers.

We suggest that producing countries as a group seriously examine two options for capturing more of the retail price of coffee. The first, as mentioned above, is implementing a minimum price linked to the farmgate price of the high productivity sector in Brazil. The second is supporting producers to harness the potential of new technologies to improve their incomes. The development of e-commerce has the potential to reduce market concentration and provide a means for producers to add and capture more value through more direct-to-consumer sale models. Although currently niche, direct-to-consumer models have potential to scale with sustained institutional support. This could include aggregating producers for economies of scale, and making the administrative and logistical aspects feasible for many producers. Some of the institutional support needed could potentially be undertaken by producer associations. This could include, for example, identifying and negotiating better rates with existing entities and companies that could provide necessary services, such as transport or distribution. Online retail is also fiercely competitive, and producers can be at a disadvantage given the high consumer loyalty to major brands. To break through the competition, significant offline investments would have to be made by producers and supporting institutions on marketing, quality control, and logistics.

Way Forward

Coffee sector actors have acknowledged deep sustainability concerns, particularly in light of the ongoing price crisis and impending climate crisis. Multiple calls for global collective action have been made. In this report, we address these calls, and we recommend strategies that provide ambitious yet achievable pathways for making coffee truly sustainable.

We very much welcome feedback on the ideas presented herein and we look forward to continuing to build our analysis in partnership with producers, industry actors, and the many other stakeholders focused on making coffee sustainable.

Photo derivative of Nathan Dumlao on Unsplash

Introduction

Coffee is the world's favorite beverage, with an estimated 400 billion cups consumed per year. Coffee is grown in dozens of countries, providing livelihoods for at least 60 million people, and potentially many millions more.[1] Unlike soda drinks with sugar additives, coffee is healthful and protective against many chronic diseases. For these and other reasons, promoting the long-term health, wellbeing, and environmental sustainability of the much beloved coffee sector should be a clear priority.

Yet coffee is experiencing a sustainability crisis. This crisis stems from currently unsustainable economic, social, and environmental aspects of coffee production. Despite the hundreds of millions of dollars annually put towards coffee sustainability,[2] and despite the fact that over 50 percent of all coffee has been grown (but not necessarily sold) under a sustainability standard in recent years,[3] coffee production is still burdened by persistent poverty, child labor, and environmental damages and threats, such as deforestation and climate change. In many coffee-growing regions in low-income countries, basic services remain out of reach for millions of coffee farmers and laborers and their respective families.

This sustainability crisis in coffee production has been deepened by the recent decline in world coffee prices, which has further squeezed coffee producers around the world. While many consumers willingly pay high prices, often several dollars per cup of coffee at a coffee shop, coffee farmers receive a tiny fraction of that retail price, currently between 1 and 2 cents per cup (assuming 25 cups per pound and $US 1 per pound). At these low prices at the farmgate, coffee production is not economically viable for a significant number, perhaps a majority, of coffee farmers today. Even before the recent price decline, farmgate prices were low, and farmers faced many risks and rising costs, including price volatility, spreading coffee diseases, rising fertilizer and other input costs, and lack of access to capital and insurance on attractive terms.[4] For many smallholders in low-income countries, seasonal hunger and poor nutrition were already a part of life, and implementing more sustainable practices required risky investments beyond the financial means of poor farmers.[5] Yet the recent price crisis has exacerbated these challenges, and has thrown a tremendous number of additional producers below the global extreme poverty line of US$1.90 per day.[6] At the time of writing, the price paid for green coffee is lower than many producers' long-term costs of production,[7] yet most of these producers have no other option than to sell at a loss. Producers are price-takers in a global market that has turned against them. Only the highly efficient, large-scale, and often mechanized producers, notably in Brazil and Vietnam, are navigating today's low prices.

These sustained low prices hurt even more as coffee producers begin to bear the brunt of climate change and variability. Climate change is expected to undermine the suitability of coffee across large regions, to decrease coffee bean quality, and to increase the risk of coffee diseases. Although the coffee industry as a whole has an interest in ensuring that coffee production can adapt to climate change, it currently lacks effective industry-wide responses. For now, producers lose the most when climate-induced weather events and diseases wipe out crops or reduce their quality. Smallholders are particularly vulnerable, with fewer resources to put towards adaptation or to absorb shocks. There is little if any effective weather insurance for most smallholders. In the current context, those who bear the greatest risks from low prices, price volatility, and the increasing impact of climate change are also those with the fewest means to manage such risks.

Photo by Max Letek on Unsplash

Although coffee producers shoulder the biggest risks of low prices and climate-induced events, farmworkers in the coffee industry can be even more vulnerable. In the worst cases, workers have been found in "conditions analogous to slavery"[8]—even on certified farms.[9] While child labor is not uncommon on family farms, instances of children working on coffee farms that do not belong to their parents have also been documented[10] and are likely widespread in some locales.[11] The United States Department of Labor has identified 17 countries, including the top three coffee-producing countries, that use child labor in the coffee sector.[12] More generally, farmworkers on both non-certified and certified farms can be vulnerable to exploitation, and many are not paid the required minimum wage.[13]

These endemic sustainability challenges, and the fact that coffee producers face particularly dire prospects due to current coffee prices, will not come as a surprise to anyone familiar with the industry. Coffee producers have publicly urged action on today's historically low coffee price.[14] The multi-stakeholder Global Coffee Platform has issued a call to action to collectively address the price crisis,[15] while the Specialty Coffee Association has developed an ongoing Coffee Price Crisis Response Initiative.[16] Awareness of coffee's sustainability challenges has also begun to spread to the broader public, with mainstream news articles highlighting how smallholder coffee farmers, pummeled both by low prices and by climate change, have begun abandoning their coffee farms, choosing instead paths such as migrating to the United States[17] or working on illicit crop plantations.[18]

There are, of course, bright spots within the coffee sector. Highly efficient producers, especially in Brazil and Vietnam, but also in other locations, are able to make a profit even at today's low prices. Indeed, the high and rising productivity of coffee production in Brazil and Vietnam helps to explain the low world prices. Also, coffee producers who grow high-quality coffee, and who are fortunate enough to have developed strong ties with ethically-minded specialty roasters, can command prices significantly above the quoted international price. Some producers have found ways to capture more of the final retail price, including through producer-owned businesses that sell directly to consumers. Other producers have benefited, to varying degrees, from the multitude of initiatives, projects, and programs offered by governments, industry actors, or non-profit organizations. These latter efforts by various stakeholders have not been in vain—many have had real and significant benefits for people around the world. Yet they also have not been enough—a reality that has become starkly clear during the current price crisis—and their limited scale has stymied efforts to make coffee production and the coffee industry more broadly sustainable.

At the same time that many producers' livelihoods have been decimated by the price crisis, the roasters and retailers at the other end of the value chain have continued to enjoy high profitability. The retail end of the value chain has also seen increasing concentration and market power. Greater consolidation could have theoretically made it easier to embed sustainability throughout the coffee sector. Instead, as roasters and retailers have become increasingly concentrated, some of their practices, reflecting their increased market power, have apparently placed even more pressure on producers and farmgate prices.

Four years after the adoption of the Sustainable Development Goals (SDGs) at a historic UN Summit,[19] and in the face of the ongoing price and climate crises, the coffee sector now stands at a crossroads.

In one potential path forward, the coffee sector could continue following a business-as-usual trajectory of limited and piecemeal sustainability endeavors, which would ultimately result in a sector that looks far different from the one we see today. Prices will generally reach an equilibrium that remains too low for producers in many countries, climate change will batter coffee-growing regions around the world, and the incidence of coffee diseases and crop failures will rise. Many producing country governments will be inadequately prepared to support their producers to effectively confront these challenges, while farmers may feel forced to leave coffee even though they lack significantly better options. These factors will ultimately result in more concentration of coffee production, with fewer countries of origin, and, within countries, fewer and larger producers. This concentration will lead to less variety in origins, in tastes, and in quality, with a potential dampening effect on consumer demand in mature markets.[20] This concentration in production will also result in greatly heightened supply risks of large-scale disruptions and greater price volatility, as climate-induced, political, or disease events in one country could potentially disrupt the entire global supply chain. One only has to consider the massive forest fires in the Amazon and the resulting worldwide backlash against Brazil in August 2019 to envision the risks to an industry in which a vast proportion of output is in just a handful of countries. Moreover, as the industry struggles to absorb such shocks, it would have to do so while also explaining to the media and the public the continued failures to eradicate child labor, to support decent livelihoods for producers, and to achieve resilience against climate change impacts on a proactive and comprehensive basis. This too could reduce customer goodwill and support, in particular from millennials who seek and expect true sustainability.[21]

Yet that is not the only path that can be taken. Following a sustainable development path, the coffee sector could look very different. While the sector cannot avoid many of the challenges arising in the business-as-usual path—climate change will occur, real prices for commercial-grade coffee will remain low, and many farmers will still need to exit coffee—sustained efforts undertaken now will prepare the global coffee sector for more success. Strategic planning and investments at the country level will help producers withstand external shocks and prepare for a more resilient future. Coffee producers will be supported to better understand their opportunities in coffee and other sectors; as some areas become less productive due to climate change, producers will receive needed support to adopt climate-adaption measures, to diversify, to move, or to transition from coffee. For those producers who remain, many could be more productive and profitable, through increased access to new research, better inputs, better options for credit and insurance, and more support for direct marketing, among other factors.

Alongside these efforts, changed business practices by roasters, retailers, and traders, such as long-term relationships with fixed contracts, would also support increased producer viability and resiliency. This wider economic viability would allow for a broader range of coffee production, with specialty and commodity coffees coming from more countries, thereby supporting greater availability of high quality coffee and continued strong demand in mature markets, as well as reducing the risks of deeper supply shocks. When diseases hit or crops fail, these incidents will be less damaging at the producer and industry levels, because producers will have the resources to continue to care for their coffee trees. Child labor could finally be eliminated, through concerted efforts to make coffee production economically viable, to step up enforcement of relevant labor laws, and to improve access to basic services in coffee-growing regions. And this increased access to basic services—such as healthcare, clean water, electricity, and quality education—will help to realize broader sustainable development within coffee supply chains.

Based on our research and the model developed for this report, we believe there is a clear opportunity for coffee sector actors to work together to take the sustainable development path, and to achieve greater sustainability within coffee production and in coffee-growing regions.

An industry-wide and pre-competitive approach is needed to protect the future of coffee and to realize sustainability on this scale. Industry actors, of course, cannot be expected to address these challenges on their own; their efforts and funding commitments should be leveraged to obtain additional matching funding from donors and from producing-country governments to support more widespread sustainable development within coffee-growing regions. Industry must take the first step, however; they cannot expect others to step in to save an industry that is not interested in saving itself. At the same time, producers and their associations, civil society organizations, research institutions, and other stakeholders also have significant roles to play in developing solutions and supporting their implementation.

Coffee sector actors appear to agree that serious collective interventions are needed. As one of the leading roasters, Nestlé has argued, "[a]dressing underlying issues to the current [price] crisis is beyond the scope of any one company's actions."[22] As the International Coffee Organization (ICO) has asserted, "joint action is needed by all stakeholders in the sector … to put the coffee sector on a positive development and sustainability trajectory."[23] In this report, and alongside other recommendations for increasing producers' viability and profitability, we propose a path for a collective intervention that would turn coffee's current price, climate, and sustainability crises into an opportunity to showcase the industry as a sustainability leader and coffee as a truly sustainable agricultural commodity.

Section I provides a snapshot of the coffee sector showing the drivers that have led to the current low real prices, underscoring the contrast between a thriving retail sector and a poverty-stricken production sector in many low-income exporting countries. Section II focuses on global supply and demand, providing an economic analysis that explains, among other things, how the recent changes in the global coffee market might rationally reopen the possibility of setting a minimum price for global coffee under certain conditions. This section also presents the results of our econometric modeling, which pays close attention to the potential impacts of climate change on coffee production and analyzes how closing the productivity gaps could help share the coffee market growth more equitably between producers. Section III discusses what sustainability in coffee means, and considers how current sustainability efforts fit into what is needed more broadly in the coffee sector. Section IV presents our recommendations for achieving sustainability and economic viability within coffee production. In particular, we suggest the use of National Coffee Sustainability Plans and the development of a Global Coffee Fund, which would receive contributions from industry actors, be matched by donors and producing-country governments, and support critical investment in sustainability that benefits producers, coffee-growing regions, and the sector overall. In addition to the Global Coffee Fund, we discuss the possibilities for producers to harness the potential of new technologies (e-commerce and targeted mobile applications) to enable greater participation in sales to consumers.

Photo by Rodrigo Flores on Unsplash

I. Coffee Sector Snapshot: Consolidation at Both Ends of the Value Chain

A. The Recent Decline in Global Coffee Prices

Two mechanisms have determined coffee prices in recent years. Under the quota regime of the International Coffee Agreement (ICA) (1962-1989), prices were kept artificially high (although higher prices did not always benefit producers).[24] Subsequent to the quota regime's collapse, the free market has driven down average prices, as shown in Figure 1.[25]

Under both historical regimes (during and after the ICA's quota regime), real prices are basically trendless. That is, since 1990 (or better yet, 1992, after adjustments to the collapse of the ICA's quotas), there is no discernible downtrend in prices, at least until the very recent decline in 2018-9. Since the collapse of the quota system, coffee prices have been mostly a function of the fundamentals (changes in long-term supply and demand), and have been affected by the fluctuations of the Brazilian Real (Figures 2 and 3) and the US Dollar (see Figure 3), as well as other short-term shocks (e.g. climate, global commodities prices, interest rates, global business cycle). The Brazilian Real affects coffee prices because of the dominance of Brazilian production in the world coffee supply (as discussed below), making Brazil the price setter; a weak Real is positively correlated with higher Brazilian coffee production and exports and consequently lower coffee prices in US dollars. This occurs because a weak Real increases Brazilian producers' prices relative to local (Real) costs. Conversely, a strong Dollar exchange rate raises coffee prices expressed in euros, cuts European demand, and thereby lowers world coffee prices expressed in dollars.

Figure 1: Two Historical Price Setting Regimes: ICA Quotas and Post-ICA Quotas (ICO Mild Arabica, $US/pound 2018 Prices)

Source: World Bank (May 2019)
Monthly prices adjusted with US CPI[72]

Photo by Rodrigo Flores on Unsplash

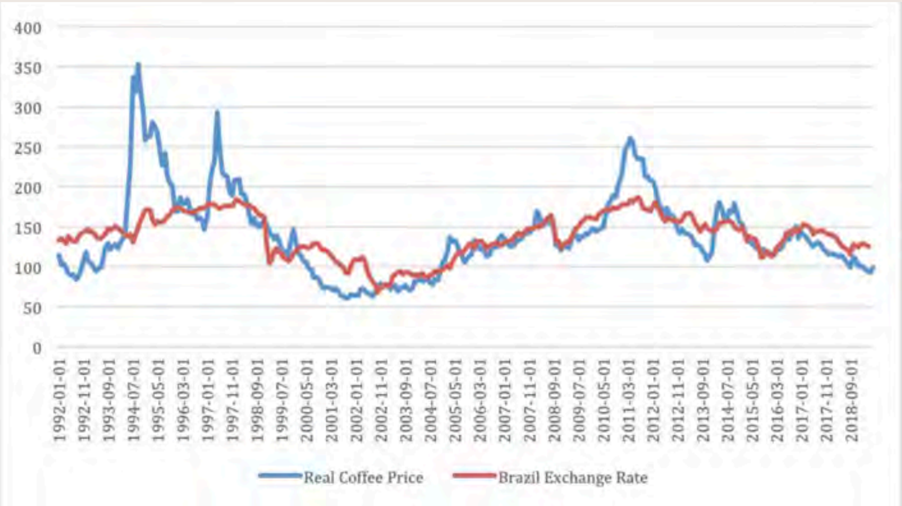
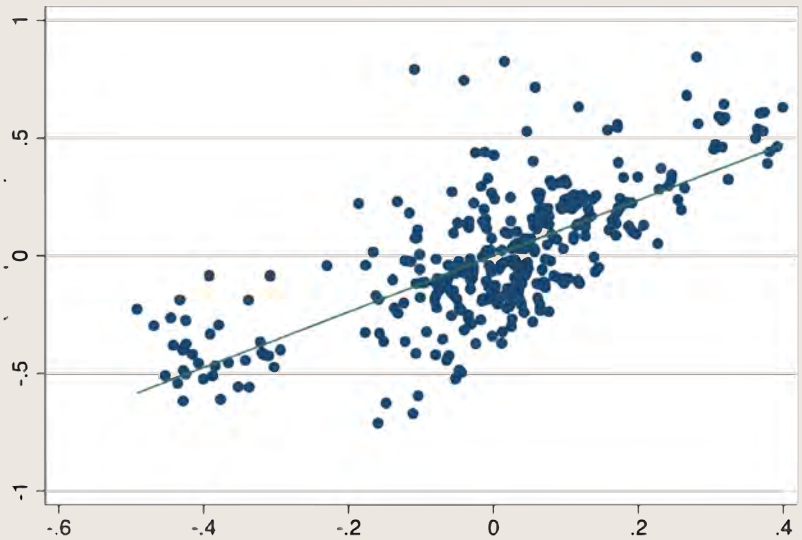


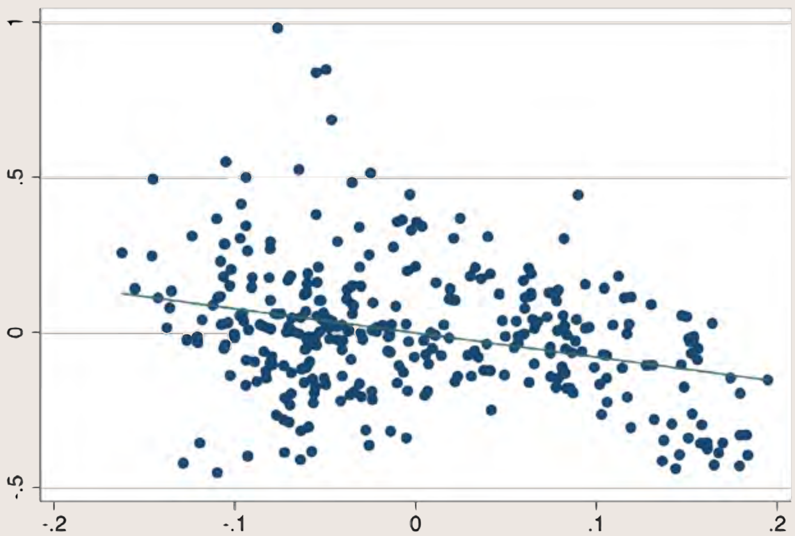
Figure 2: Strong Correlation of ICO Composite Coffee Prices and the Real Exchange Rate of the Brazilian Real (1992-2018)

Source: FRED for exchange rates[73] and ICO composite coffee prices

Figure 3: Coffee Prices Since 1992 and Brazilian Real Exchange Rate (Top); Coffee Prices Since 1992 and US Dollar Real Exchange Rate (Bottom)

Source: FRED for exchange rates[74] and ICO composite coffee prices.





The recent low prices have been produced in part by a strong US Dollar combined with a weak Brazilian Real. The exchange rate movements explain perhaps up to half of the decline in coffee prices since early 2017 (roughly 30 percent decline in average prices). The rest of the recent decline is due to other factors. One possible factor is the increasing consolidation of the retail-roaster side of the industry, which *may* be giving increased market power (monopsony power) to the buyers, and thereby depressing prices for the producers. We do not have direct evidence of such a market power effect, but do find some anecdotal evidence.

In summary, we believe that world market prices for coffee are moderately low today (mid-2019) because of four factors:

- Strong dollar
- Weak Real
- Increased market power of buyers (indirect evidence only)
- Other factors not identified

Given the relatively low coffee prices today, many producers around the world are experiencing extreme financial duress, with low incomes and business losses. Yet the impact is felt very differently in the high-productivity countries (Brazil and Vietnam), where the more productive farms are still profitable, and the lower-productivity countries (most of the rest), where losses are rampant. We believe that, beyond the collapse of the ICA's quota regime, the most fundamental reason for the lower prices after 1990 than before is due to the continued rise of productivity of Brazil and Vietnam, even as global demand for coffee has increased. In 1995, those two countries produced 21% of the world's coffee. By 2017, they produced 46%, as shown by the dotted line in Figure 4. From the 3.7 million tons of coffee added to world production between 1995 and 2017, 83% came from Brazil and Vietnam.

Today's low prices therefore do not appear too far below the price that would otherwise be seen under the long-term equilibrium (also discussed in Section II); they are perhaps 25 percent or so below the long-term equilibrium price. Similarly, today's low prices are not fundamentally related to the financialization of the futures market (see Box 1), but rather result from a supply-driven equilibrium, with increased global supply arising in large part from the significantly increased production in Brazil and Vietnam.

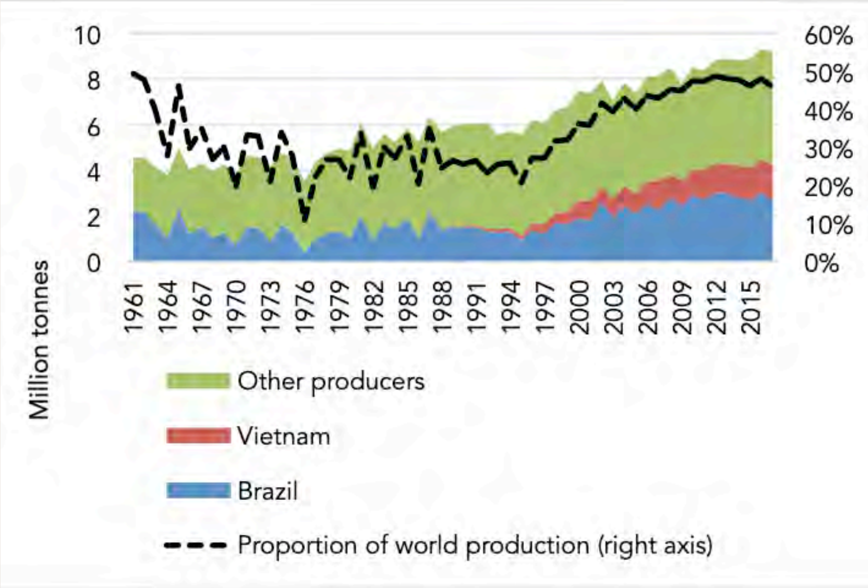


Figure 4: Global Coffee Production, 1961-2017

Source: FAO[75]

Box 1: The Role of the Futures Markets and Coffee Trading

Washed Arabica coffee is traded on the Intercontinental Exchange (ICE Futures US) futures market, formerly the New York Board of Trade (NYBOT), while Robusta coffee is traded on the ICE Futures Europe futures market, formerly the London International Financial Futures and Options Exchange (LIFFE). The trading price of Arabica coffee on the ICE is known as the "C-Price." The prices represent a range of qualities and are thus average prices. Differentials (i.e., a premium or discount) are then set for coffee from different origins. The differentials reflect local physical market conditions in addition to coffee quality grades. The Arabica and Robusta coffee futures contracts are used as global benchmarks for the pricing of physical coffees.

In the short term, futures prices do not always reflect the equilibrium of supply and demand in the physical market, due to large volumes that may be traded for speculative reasons. The volume of futures trading far exceeds the trading volume of physical green coffee. For instance, the volume of futures trading was 15 times that of world imports in 2010.[76] The ICO has noted that the volume of futures trading nearly tripled for Robusta and increased five-fold for Arabica from 1994 to 2018, whereas Arabica output only grew by 64% and Robusta by 144% over the same period.[77] This increased volume of trading "suggests that the coffee market has been subject to a significant process of 'financialization' over the past two decades."[78] This financialization is characterized by active trading strategies, which contrasts with the traditional index investors that dominated the market before the 2000s.[79] Some argue that these increased trading activities are in excess of what is needed to provide liquidity in the market.

The role of financial variables in determining coffee price dynamics has been the subject of study by a number of reports. Most concur that the impacts are short term, and that the long-term coffee price is determined by the fundamentals.[80]

These short-term impacts, however, can affect producer welfare. Some studies have found that the financialization of coffee trading has exacerbated price volatility.[81] Even in the short term, this can have deleterious impacts on farmers, as it inhibits farmers' ability to plan for planting cycles. For this reason, some stakeholders in the field have suggested regulating the non-commercial actors that trade coffee, by limiting their position or by increasing the cost of non-hedging positions.[82]

Financialization can also temporarily exacerbate fundamental price trends, which could have the effect of decreasing farmers' incomes in times of low prices and increasing their incomes in times of high prices.[83]

Despite these short-term effects, the fundamentals in the physical market of supply and demand seem to prevail in the long run in determining price behavior.[84]

B. Global Supply and Productivity Improvements in Brazil and Vietnam

The global production increase has been driven significantly by productivity improvements in Brazil and Vietnam, by over 100% in Vietnam and 30% in Brazil between 1995 and 2017 (see Figure 5). These increases contrast starkly with the relatively stable yields for the remaining coffee-producing countries. (The average for other countries in Figure 5 hides some discrepancies. For example, countries such as Honduras and Guatemala have seen rising yield rates, while others such as Uganda and Mexico have seen yield rates fall.)

The yield increases since 1995 in Vietnam and Brazil can be explained in large part by large public and private investments in their respective coffee sectors. This includes investments in agronomic practices, training, infrastructure, and the availability of financing.

In Vietnam, where the coffee sector is almost entirely composed of smallholder farmers, investments have been made in irrigation, and farmers use large amounts of chemical fertilizers.[26] Factors such as the planting of improved yield varieties of Robusta trees, extension programs, and better pruning practices—much of which has been supported through public-private collaboration and investments—have been key to the country's massive productivity increases.[27] The Western Agroforestry and Scientific Institute in DakLak (WASI), for example, has played a key role in developing high-yield and climate resilient Robusta varieties. The Institute has benefitted from the support of, and from cooperation with, private sector stakeholders such as Nestlé.[28] Other factors also play a role; the Vietnam Bank of Agriculture and Rural Development (Agribank), for example, provides accessible credit to coffee farmers. In 2014, the Government also developed a Sustainable Coffee Development plan with a vision to 2030 in order to improve sustainability of the sector and increase producer earnings.[29]

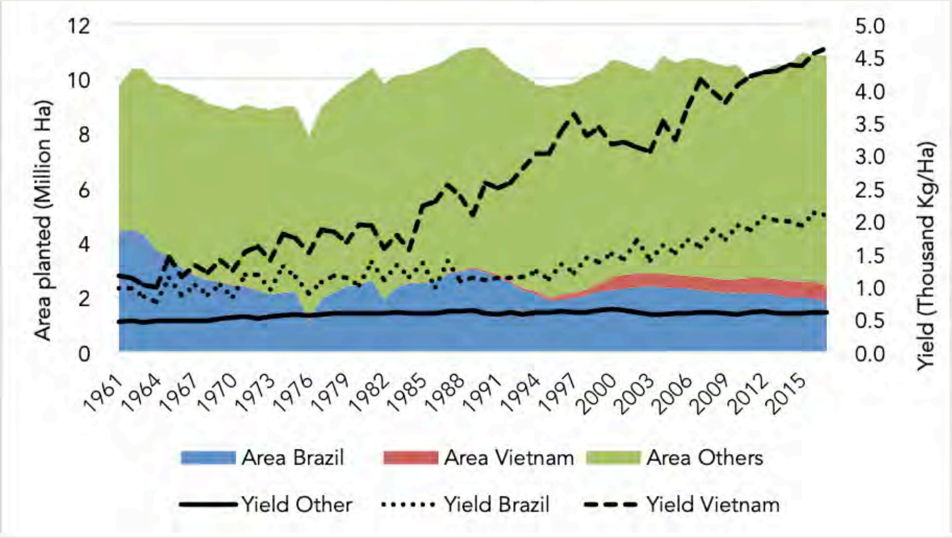


Figure 5: Area Planted and Yield Rates

Source: FAO

Brazil's coffee sector is very diverse, ranging from large-scale farms in Cerrado Minero, which have adopted mechanization, to family-run farms in Matas de Minas. In the former region, technological progress and investments have led to high productivity increases, and farmers have collaborated to maximize marketing strategies and develop direct relationships with roasters. In the Matas de Minas region, which is more mountainous, mechanization is difficult and family-run farms rely on more intensive labor and sharecropping.[30] In yet another region, Sul de Minas, some farming is mechanized, and local cooperatives play an outsized role.[31] Access to finance and the development of coffee varieties suited for the different environments in Brazil have contributed to the success of the sector throughout the country.[32]

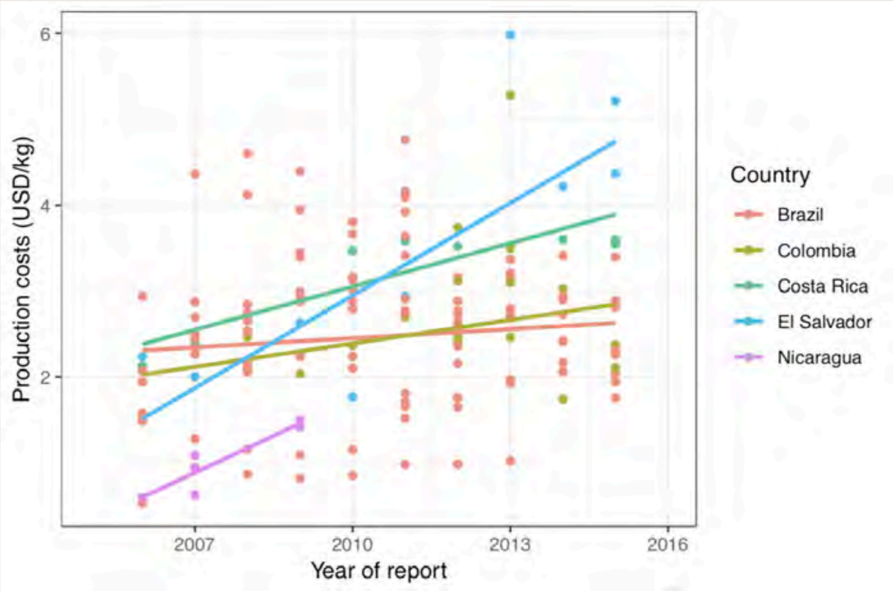
While coffee prices have been pushed down due to increased production from Brazil and Vietnam, costs have increased, further squeezing farmer incomes. This has led to a situation where many farmers cannot cover short-term operating costs, let alone cover their investment expenses. By drawing upon a variety of reports, Figure 6 shows that these production costs have risen particularly sharply since 2010.

Although the rise in production costs shown in the figure below is somewhat obfuscated by the different countries that are surveyed in different years, some general trends are clear (see also the appendix for more details). Costs have risen an average of 3% per year in real terms since 2005, while farmgate prices have fallen during that time. Arabica coffee is about \$0.71/kg more expensive to harvest than Robusta coffee. Costa Rica has consistently high production costs, and Vietnam (not shown in the figure) has consistently low ones, but other countries have even higher costs than Costa Rica while others have lower costs than Vietnam. Within countries, ranges of costs in excess of \$1.00/kg are typical.

In a 2016 study, the ICO attributed these rising costs to several factors.[33] First, producers face increasing labor costs due to economic development and rural-urban migration. Second, the price of inputs such as fertilizer and pesticides has increased. Third, more capital goods are used in the production process.

Figure 6: Total Production Costs per kg, as Reported for Different Countries, Varieties, and in Different Years.

Sources: ICO 2016, Specialty Coffee Association 2017, Caravela Coffee 2019[85]



These drivers vary by country. Costs of production can be divided into direct costs, such as labor and inputs, and indirect costs, such as administration, maintenance, and infrastructure (see Figure 7). Overall, labor costs vary significantly from one country to another. In El Salvador, for example, labor comprises 33% of the total costs of production, while in Peru it represents 48%.[34] The amount of fertilizer and pesticides used by farmers also varies significantly. These input costs have fluctuated significantly in recent years given that they tend to follow volatile oil prices.[35] Other factors, such as the size and level of diversification of the farm, the national legal framework, the support provided by coffee associations, and the exchange rates determine the various components of the total production cost. (In addition, there are a number of externalized costs of production that are not currently represented in producer economics, but which are also important. These include social costs, such as child labor and health and safety concerns, as well as environmental externalities around water, energy, and land use.)

Since the ICO's 2016 analysis discussed above, operating losses in many countries have intensified, as input costs have continued to rise (for instance, fertilizer prices surged by almost 20% between November 2016 and December 2018)[36] alongside the continued downward pressure on coffee prices. These factors have also negatively affected more efficient farmers.[37] For instance, a 2019 study found that 53% of Colombian farmers and more than 25% of Costa Rican and Honduran farmers are operating at a loss.[38]

Two conclusions can be drawn from the above analysis. First, the current low-price environment does not seem to be a temporary short-term phenomenon, although prices now may be slightly lower than otherwise would be expected because of the relative weakness of the Brazilian Real and strength of the US Dollar. Similarly, rising labor costs are part of a longer-term trend, to the extent that the economies of coffee-producing countries continue to develop. These low prices and rising costs have increased the concentration of coffee producers. As noted above and further below, this consolidation will continue under the business-as-usual pathway, resulting in less variety in origins, in tastes, and in quality, with a potential dampening effect on demand; lost smallholder knowledge; and heightened supply risks of large-scale disruptions and greater price volatility. Second, the examples of Brazil and Vietnam

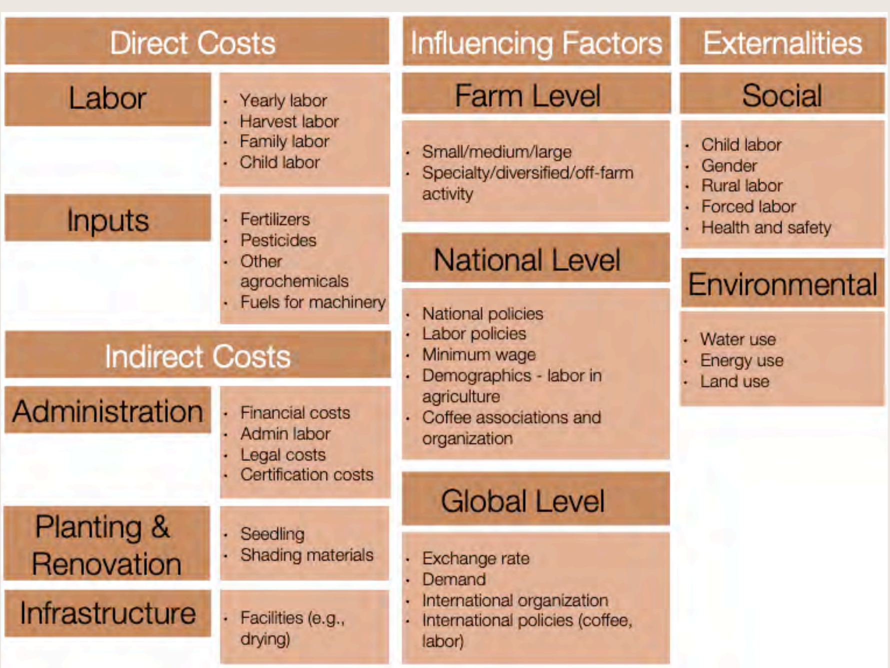


Figure 7: Conceptual Framework for Factors Contributing to Coffee Production Costs[86]

show that with the right combination of investments in coffee-producing regions, there are opportunities to increase farmer productivity, efficiency, and resiliency.

C. Stark Contrast: High Profitability among Roaster-Retailers and Persistent Poverty among Producers

While millions of coffee producers are suffering an economic crisis, the roaster and retail sector is flourishing.

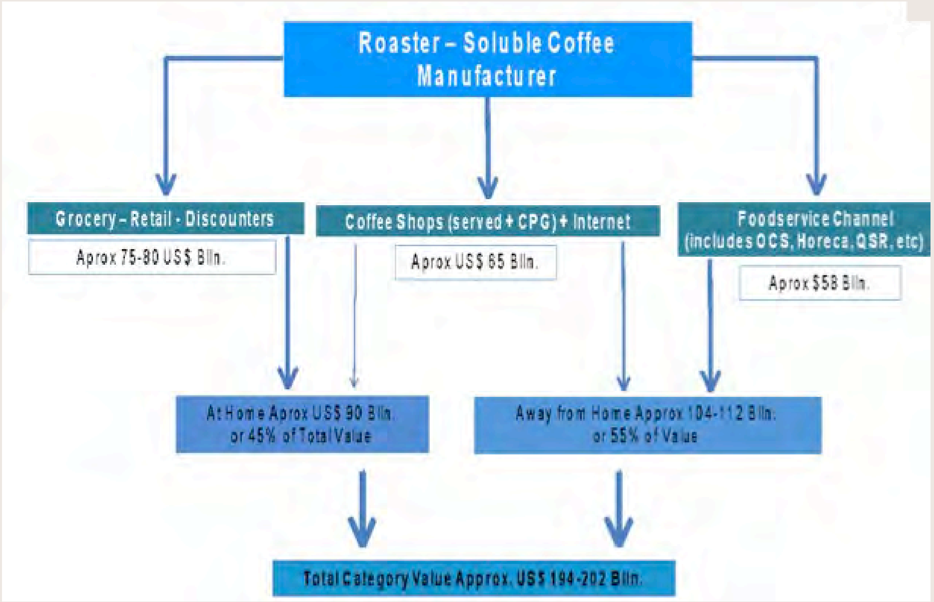
To our knowledge, the latest estimation of the revenues of the global coffee industry dates back to 2015, where gross retail sales were estimated to be around $200 billion.[39] This was roughly divided up by grocery, coffee shop, and food services market segments (Figure 8).[40] In terms of volume, the largest proportion of coffee is sold in grocery markets and consumed at home, making up around 65-80% of the total.[41] Interviews with coffee experts have suggested that total industry revenues may have grown to $250 billon today.

Operating profit margin[42] estimates for Starbucks (15% in 2019)[43] and Keurig Dr Pepper (17% in 2019)[44] suggest that the coffee majors are performing very well indeed. For the smaller players in the retail industry, this margin is estimated to be much lower, at around 2.5%.[45] Taking the average of the lowest and highest operating margin values in the market, which roughly reflects the split between industry leaders and small roasters/retailers, and applying it to the estimated $250bn retail sales revenues, a rough approximation is that the industry has an annual operating profit margin of $25bn, although this is just a rough estimate.

The future also looks bright for roasters and retailers. Coffee is one of the fastest-growing sectors in an otherwise slow-growing food and beverages market. It is estimated to grow at a compounded annual growth rate (CAGR) of 5.5% between 2019 and 2024.[46] Significant investments are even being made in startups. Coffee startups raised $600 million in the first seven months of 2018—four times the amount of money raised in the year before, with the average deal size increasing more than fivefold within a year.[47] Traditional soda beverage producers such as Coca Cola are moving into coffee because of the health benefits of coffee and the disease hazards associated with sugar-sweetened soda.

Figure 8: Global Coffee Industry Value Distribution

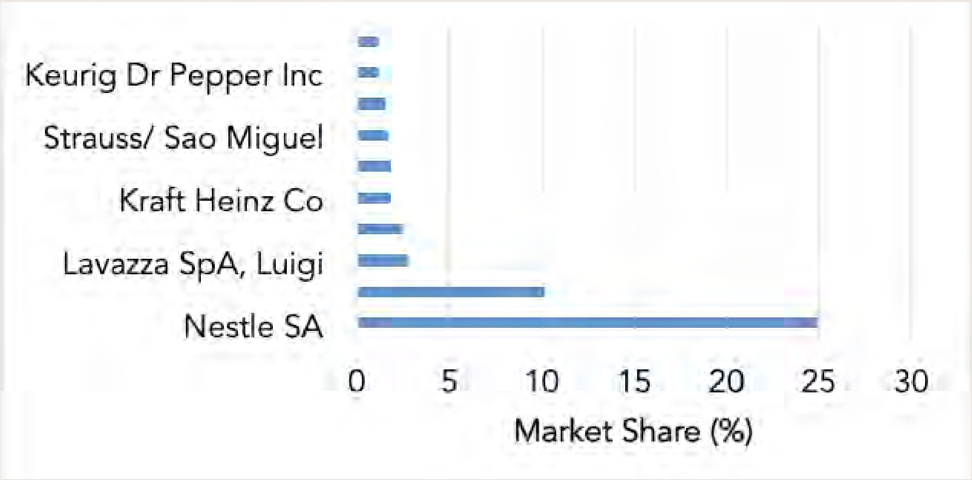
Source: Samper, L; Giovannucci, D; Vieira, L M (2017) [87]; Acronym caption: OCS: Office Coffee Service, Horeca: Hotels, Restaurants and Cafeterias, QSR: Quick Service Restaurants



The profitability of the coffee sector and its growth potential have led to a significant consolidation, and to numerous financial investments, on the roaster and retail side, in particular around premium brands. In the past decade, for example, JAB Holding Company, the fastest-growing actor in the sector, has invested over $50 billion to acquire premium consumer coffee brands and restaurant chains (including Peet's Coffee & Tea, Caribou Coffee Co., Intelligentsia, Stumptown Roasters, and Keurig Green Mountain); the companies in its expansive portfolio sell large coffee volumes in two lucrative coffee segments—specialty and capsule—that have emerged in recent years.[48] Similarly, Nestlé has also acquired in the specialty segment, and is now a majority owner in Blue Bottle, a select specialty Californian chain, after signing a deal valued at approximately $500 million in 2017.[49] These mega-purchases highlight the enormous profitability—and the huge price markups over costs—of the world's top coffee brands.

In the grocery market segment, brands are increasingly intertwined, and working to sell at higher premiums. Starbucks branding is an example.[50] In 2011, Starbucks and Keurig signed a deal to sell single-serve Starbucks packs for Green Mountain's Keurig brewer in grocery stores, creating a synergy between the leading café brand and the leading brewer in the USA.[51] In 2018, Nestlé acquired, through a $7.2bn deal, the global rights to market Starbucks' consumer and food service products (outside of Starbucks coffee shops) in its grocery channels.[52] Under this deal, Starbucks continues purchasing the green coffee beans from farmers, but Nestlé roasts and distributes the coffee for consumers under strict Starbucks licensing and branding rules, while paying annual royalties.[53] This follows a similar but ultimately failed deal with Kraft, signed in 1998 and terminated twelve years later, with Starbucks claiming that Kraft had mismanaged its brand.[54] This speaks to the tremendous importance of branding in the coffee industry, which enables faster growth and higher profit margins.[55][56]

Figure 9: Coffee Retail Sales, World Market Share by Company, 2018 (%)



Note: Jacob Dower Egberts and Keurig Dr Pepper belong to JAB Holding Co.
Source: Euromonitor through Bloomberg

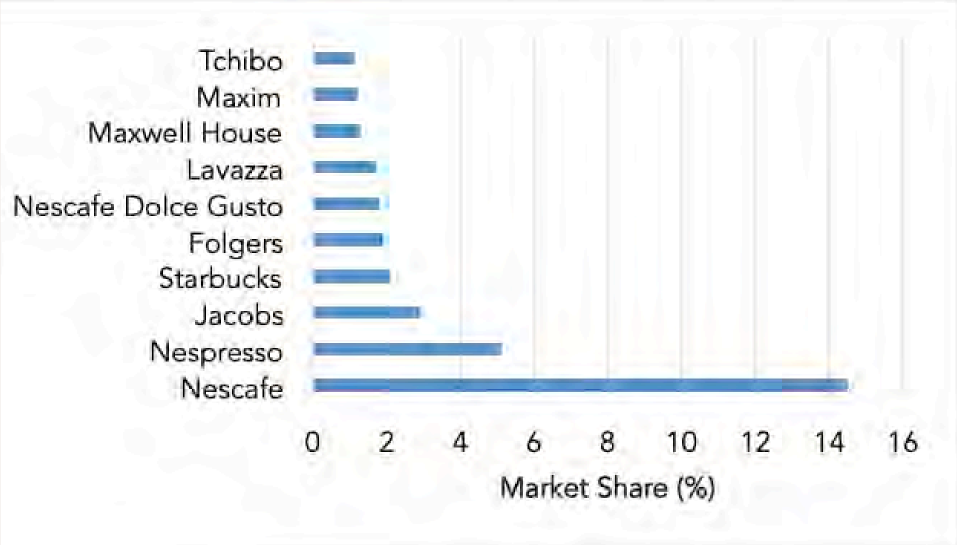
The growth and consolidation at the roaster-retailer end of the value chain has led to two outsized actors globally. As of 2018, the top two roasters, Nestlé and JAB Holding Company, had a combined global market share of nearly 38% (about 25% for Nestlé and 12.5% for JAB). Lavazza came in third place, with an estimate of roughly 2.5% of global market share (see Figure 9).

On a market segment and geography basis, the significant market power of leading brands is even more striking.[57] For example, the soluble/instant coffee segment is largely dominated by Nestlé's Nescafé;[58] the single-serve capsule segment is captured by JAB's Keurig Green Mountain in North America[59] and Nestlé's Nespresso and Dolce Gusto in Europe;[60] traditional espresso coffee brands are led by Illy and Lavazza;[61] and out-of-home specialty coffee is in the stronghold of Starbucks.[62]

Brand market power and the resulting high margins of leading roasters and retailers have been driven in particular by increased value addition in importing countries, which comes through the development of lucrative "intangible" aspects of coffee. This includes "innovation, brand image and the consumer environment in general, which transcends products' taste characteristics."[63] Symptomatic of this phenomenon is the opening of the Starbucks Reserve Roastery stores, which are "theatrical, experiential shrines to coffee passion"[64] and where consumers pay extra for the experience. The increased value addition through "intangibles" is also observed in the grocery retail market segment, where pods and capsules generate value beyond the taste of coffee.[65] The evidence suggests that a rising share of total coffee-sector income is earned downstream, with enormous markups and returns for intangibles such as brand.[66]

Figure 9: Coffee Retail Sales, World Market Share by Brand, 2018 (%)

Note: Jacob Dower Egberts and Keurig Dr Pepper belong to JAB Holding Co.
Source: Euromonitor through Bloomberg



This change in the value distribution between the upstream actors (producers and in-country merchants) and downstream actors (roasters and distributors) within coffee global value chains is captured by the figure below, which shows the value distribution for coffee consumed at home in France over a 20-year interval (Figure 10). It demonstrates that the downstream sector has increased its derived value of the finished product, while the proportion that goes to producers has fallen.[67]

The continued investments and profits closer to the consumer end of global value chains stand in sharp contrast with the dire situation of coffee producers in recent years. In 2019, for example, the ICO found that in all 13 surveyed countries, coffee producers' average annual income had decreased over the last two years.[68] As a result, the proportion of producers living below the extreme poverty line of US$1.90 per day had increased dramatically in the surveyed countries—by as much as 44% in Cameroon and 50% in Nicaragua (Figure 11).[69]

The starkly contrasting situations of profitable downstream actors and suffering upstream ones may eventually upend business-as-usual approaches within the coffee industry. While some of the profitable roasters and retailers have used sustainability attributes to justify higher retail prices and/or to take advantage of the profit margins in the sustainability/conscious-consumer segment of the market,[70] consumers—in particular millennials—are increasingly able to discern true sustainability commitments from greenwashing.[71] In this context, the dire situation of coffee producers could lead an important segment of consumers to strongly question whether the brands they trust support the economic sustainability of producers. This plausibly could shift some brand loyalty towards companies that are better partners for producers, or that are willing to more actively facilitate economic sustainability. It may also create an opportunity for some producers to capture more of the final retail price of coffee, by marketing more directly to consumers, as discussed in Section IV.

Moving from this snapshot of the current state of the coffee sector, we turn now to future global supply and demand prospects. Understanding what the future may hold—particularly in light of climate change—is critical for assessing the ways in which the sector can achieve economic viability and sustainability in coffee production.

Photo by Gerson Cifuentes on Unsplash

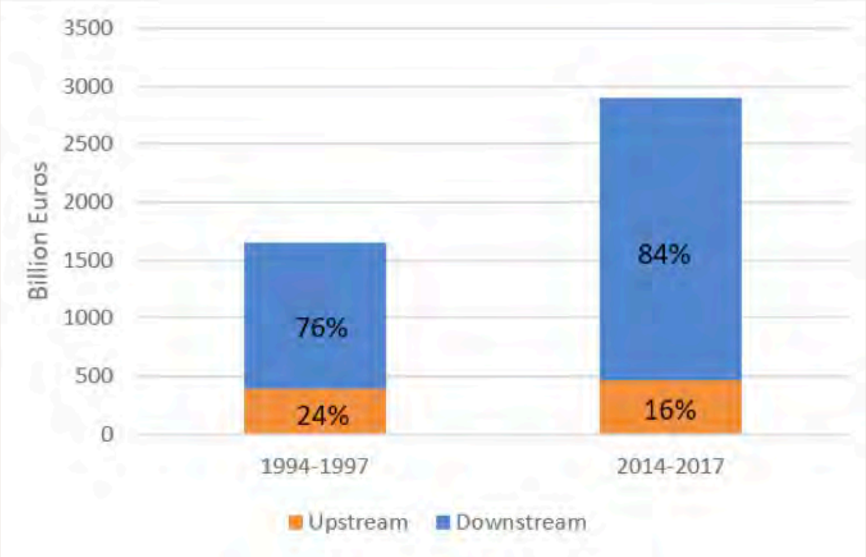


Figure 10: Changes in Value Distribution for Coffee Consumed at Home in France in 1994-1997 vs. 2014-2017

Source: Adapted from Le Basic[89]

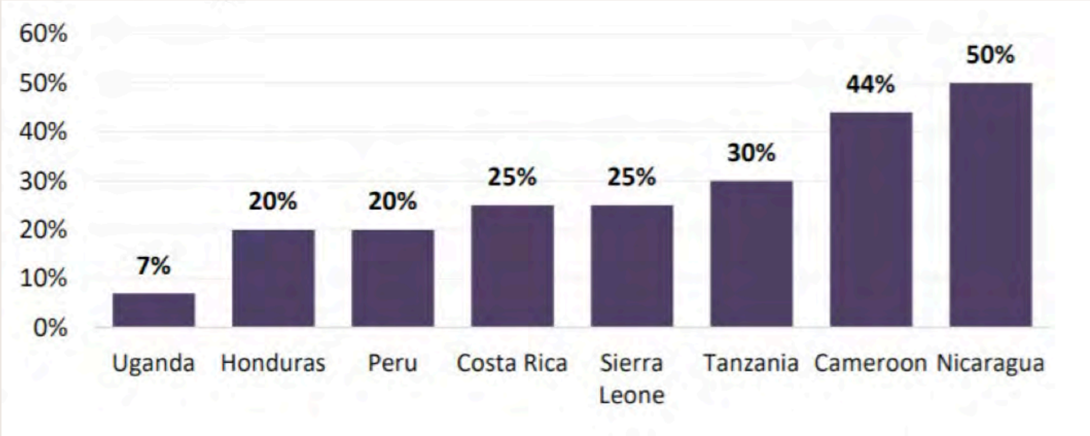


Figure 11: Increase in the Proportion of Farmers Living Under the Extreme Poverty Line of US$1.90 a Day[88]

II. Global Supply and Demand Prospects

A. The Basic Analytics of Supply and Demand

In this section, we illustrate the basic determination of the world coffee price, production and consumption, using a simple supply-demand model. In the following section, we use econometric and simulation techniques to quantify the relationships illustrated in this section.

A World Model Assuming Perfect Competition in the Coffee Sector

At the most fundamental level, the world coffee price is determined by global supply and demand, as illustrated in Figure 12. The world supply QS(P) is a rising function of the price ($US/lb) of coffee. The world demand QD(P) is a declining function of the price. Assuming a high degree of competition among producers, and no market power among roaster-retailers (see below), the world price and quantity are established at the intersection of the supply and demand curves, resulting in world price P* and global quantity Q*.

Consumers and producers in fact face different prices. The price P* facing producers is the farmgate price. The price facing consumers is P* + M, where M is the mark-up for buying, shipping, roasting, branding, and retailing the coffee beans. For the moment, we will assume that M is a constant, determined by the costs of handling the beans from the farm to the retail shelf. This would be an appropriate assumption if the buying-shipping-roasting-retailing component of the market is highly competitive, an assumption that is less true today than in the past. For now, we assume that M is fixed and consequently ignore M in the discussion. In the following sub-section, we explore the implications of market power among the roaster-retailers, in which case M changes according to market power.

In the era of export quotas under the International Coffee Agreement (ICA), the world price was held at P** > P*, as shown in Figure 13. As a result there was an excess supply of coffee in the amount QS(P**) –

Figure 12: Supply and Demand in the World Coffee Market

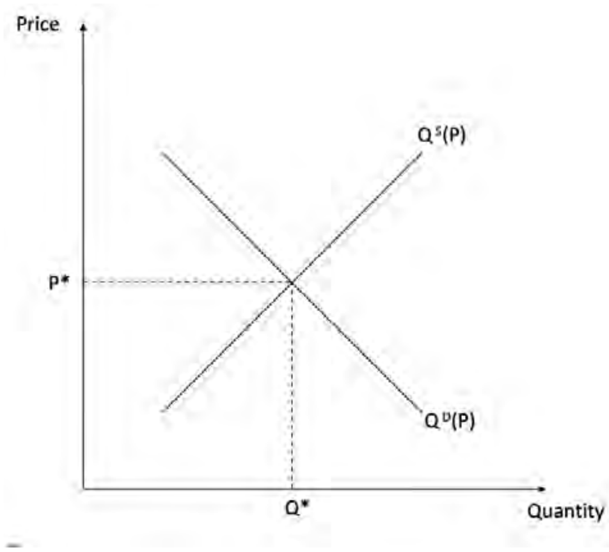
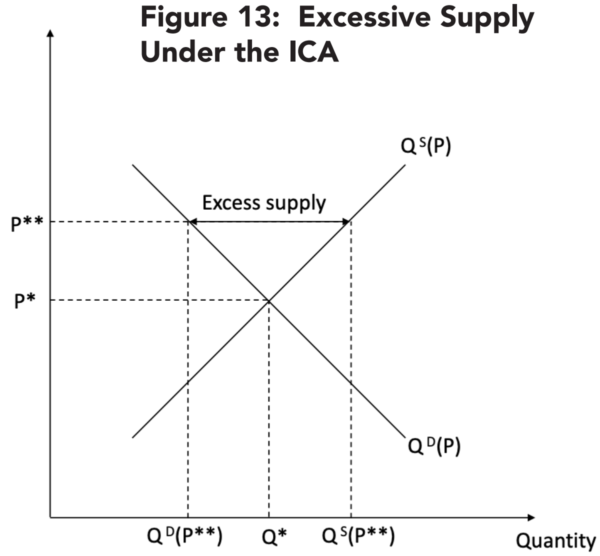


Photo by Annie Spratt on Unsplash

Figure 13: Excessive Supply Under the ICA



QD(P**). In order to maintain the price at P**, it was therefore necessary to restrict the supply of coffee. This was done by assigning a quota to each coffee exporting country. In turn, each exporting country had to limit the production of coffee in line with the export quota.[90] This was accomplished through a combination of export taxation and export quota permits assigned to individual coffee producers (as also discussed in Box 7).

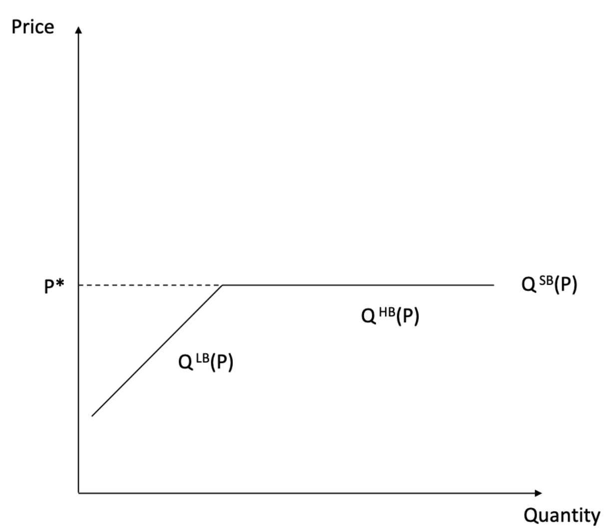
The most important quantitative restrictions on total exports were imposed in Brazil, the world's dominant coffee producer. The ICA's quota system collapsed in 1989 when, among other reasons,[91] Brazil declared that it would no longer restrict its export supply. At that point, the price declined from P** to P*. During 1960 – 1989, the average price of coffee was $8.38/kg ($3.80/ lb) (measured in 2019 dollars). During 1992-2019, the average price of coffee was $3.74/kg($1.70/lb) (measured in 2019 dollars).

To simplify the reasoning for ease of understanding,[92] it is useful to divide the global supply curve for Arabica coffee into two parts, Brazil and the rest of the world (ROW). Brazil's supply curve, QSB in Figure 14, is positively sloped at very low prices but then turns basically flat at the price P*. The reason is as follows. At very low prices, only low-intensity production techniques (hand-harvesting of coffee beans, for example) are profitable with low yields in a limited land area. When the price reaches P*, however, high-yield, mechanized coffee farming becomes profitable, using intensive inputs (e.g. fertilizers and irrigation) and mechanization for harvesting and other purposes. (In fact, the supply curve will be gently upward sloping rather than perfectly flat, given that some lands will be preferred to others in terms of natural fertility, access to input markets, access to export markets, and other factors, and these favorable lands will therefore supply coffee at slightly lower prices.)

We can therefore think about Brazil's coffee sector as having two distinct parts: a low-productivity and non-mechanized sub-sector, shown as QLB(P), and a high-productivity and mechanized supply, shown as QHB(P), which is highly elastic at the price P*. Brazil's national coffee supply curve, QSB(P), is the horizontal sum of the two sub-sectors as shown in the figure below.

Brazil in fact has millions of hectares of land that were previously cultivated for coffee production, but that are not currently used for that purpose. Since 1974, 5.8 million hectares have been used for coffee production in Brazil,[93] but only 1.8-1.9 million hectares are currently planted with coffee.[94] Much of that formerly used land is flat enough to be used for high-yield, mechanized coffee production (an estimated additional 1.9 million

Figure 14: Two-Part Supply Curve for Brazil



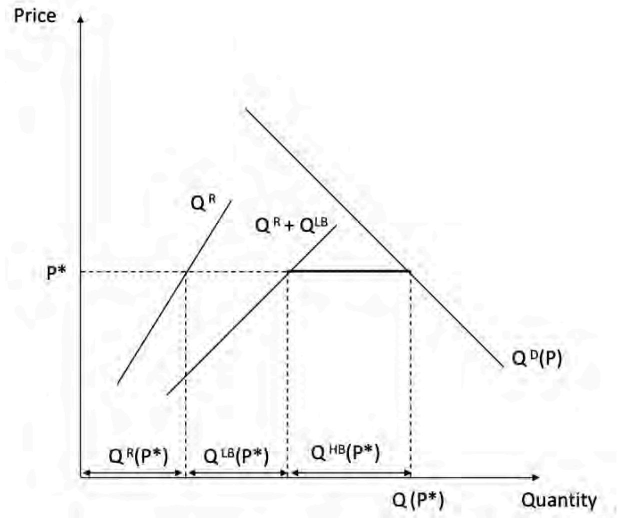
hectares), and could be brought back into coffee production at a relatively modest cost, albeit over the course of several years of new planting. Moreover, millions of hectares of land suitable for mechanized coffee farming could be brought into production for the first time if producers were incentivized by prices slightly higher than P*: we estimate that there are 18 million hectares of land in Brazil that are relatively flat, suitable for coffee production, and non-forested. Although much of that land is currently used for other purposes, the amount that theoretically could be used for coffee means that Brazil could vastly increase its coffee production with prices slightly higher than P*.[95]

The rest of the world (ROW) has an upward-sloping supply curve, QR(P), that is similar to the supply curve of the low-productivity Brazilian subsector, as depicted in Figure 14. Outside of Brazil, there is considerably less available land to bring into new coffee production. Moreover, most coffee lands are in mountainous regions that are not suitable for mechanized harvesting. Production is labor intensive and yields are lower (although by how much varies across countries, as noted in the next section). New coffee areas in most of ROW would entail deforestation or strong competition with other profitable crops.

The main opportunity for increased production and profitability in ROW is therefore higher yields and quality on existing coffee farms through the intensification of production, especially through the improved use of fertilizers, irrigation, improved coffee varieties, and science-based farming methods (while respecting sustainable environmental practices). New technology that supports the harvesting of mountain hand-picked coffee, such as the machine developed by Cenicafé (Centro Nacional de Investigaciones de Café) in Colombia to help take down coffee cherries, could also help make mountainous coffee more competitive, by significantly cutting down harvest times.[96] These various steps towards sustainable intensification are indeed possible, and highly desirable for ROW.

The global supply curve, shown in Figure 15, is found by adding horizontally Brazil's supply curve, QSB(P), and the rest-of-the-world supply curve, QSR(P). The global demand curve is QD. The world equilibrium is shown as P* and Q*. At the world price, there are three categories of supply: low-productivity Rest-of-World, QR(P*), low-productivity Brazil, QLB(P*), and high-productivity Brazil, QHB(P*). Of course, at the price P*, world demand, QD(P*), equals the world supply, QLB(P*)+QR(P*)+QHB(P*).

Figure 15: World Supply and Demand with Brazil and ROW

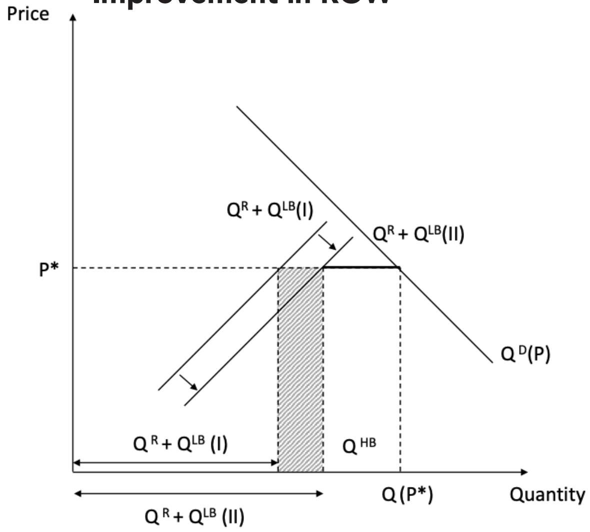


Now, we can ask three important questions:

(1) What happens if ROW improves its coffee farming techniques?
(2) What happens if high-yield Brazil further improves its technologies?
(3) What happens if world demand increases?

The answer to the first question, improved farming techniques in ROW, is illustrated in Figure 16. The supply curve for QR+QLB (ROW plus low-yield Brazilian farms) shifts to the right to the new line QR+QLB(II). Output in the ROW rises, while production in high-yield Brazilian farms contracts by the same amount. The world price P* remains unchanged. In short, ROW replaces part of the high-tech Brazilian production in satisfying demand.

Figure 16: Technological Improvement in ROW



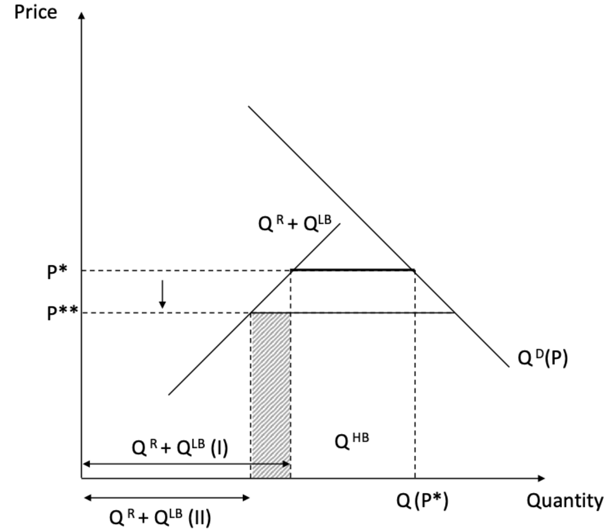


Figure 17: A Technological Advance in High-Tech Brazil:

Price falls from P* to P**, low-tech production falls, and high-tech production rises

The answer to the second question, improved technologies in high-yield Brazil, is illustrated in Figure 17. We can consider the technological advance to be a reduction in the break-even cost of high-yield coffee farming. In that case, production in high-yield Brazil expands, while production in ROW and in low-yield Brazil contracts from QR+QLB(I) to QR+QLB(II). World coffee consumption rises at the new lower world price P**. A similar outcome occurs if the Brazilian Real experiences a real depreciation compared with the dollar and euro. In that case, the supply price of coffee measured in dollars and euros will decline for any given Brazilian Real price.

The answer to the third question, higher demand among coffee consumers, is illustrated in Figure 18. The world demand curve shifts to the right (higher coffee consumption at any price), to the dotted demand curve. The world price remains unchanged at P*, and the entire increase in supply is met by high-productivity Brazilian coffee production. The supply from the low-tech ROW remains unchanged. (Of course, since the Brazilian high-tech supply curve is likely to be gently upward sloping rather than completely flat, a rise in world demand would likely increase the long-term equilibrium price, but not by much.)

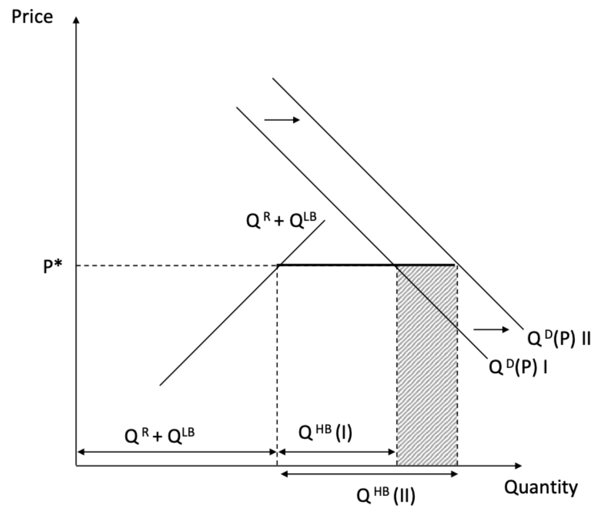


Figure 18: Increase in Global Demand

Imperfect Competition in the Coffee Industry

Let us now revise the model to take into account potential market power in the roaster-retailer segment of the market. This is a valid concern since the roaster-retailer component of the market is increasingly concentrated with two main leaders, Nestlé and JAB Holding Company. Moreover, because of the importance of branding, it is likely that brand-name roaster-retailers enjoy a significant mark-up over their production costs. In that case, the mark-up factor M reflects not only the costs of handling and processing the beans from the farm gate to the retail shelf, but also a return to brand name, earned by a mix of quality, advertising, reputation, and consumer habit. It could also be a mark-up due to implicit or explicit collusive behavior of the major roaster-retailers, who control a significant proportion of the coffee market (especially the largest two) and who are increasingly intertwined through various branding and sales agreements (as discussed above in Section I(c)).

At the farm gate, the big difference between a competitive buyer and a monopsonistic buyer of coffee (i.e., the sole buyer of coffee, who thus has significant market power) is that the monopsonistic buyer has the incentive and the ability to put downward pressure on the price paid to the producers. Suppose that a brand name can retail its Guatemalan coffee beans at $6 per lb and has $2.50 of production costs (excluding green coffee bean procurement), for a net revenue of $3.50 per lb. Now suppose that this roaster-retailer can procure 120 million lbs from Guatemala at a price of $1.50 per lb or a smaller amount, 100 million lbs, at $1 per lb. In the first case, the profits are $3.50/lb x 120M lb - $1.50/lb x 120M lb = $240 million. In the second case, the profits are $3.50/lb x 100M lb - $1/lb x 100M lb = $250 million. In this case, the monopsonist would use its market power to buy fewer beans from Guatemala but at a considerably lower cost.

Note that the monopsonist succeeds in raising the mark-up of retail prices over costs, from $2 per pound ($6 – $2.50 - $1.50) to $2.50 per pound ($6 - $2.50 - $1). This is an essential and basic point. When there is market power, the mark-up between the farmgate price and the consumer price, which we earlier labeled M, is a reflection not merely of production and handling costs (shipping, packaging, roasting, etc.) but also of market power.

When a market faces a monopsonistic buyer, it may set a minimum price without endangering the quantity purchased. For example, if the Guatemalan government or the Guatemalan coffee producers set a minimum price of $1.50/lb, the monopsonistic buyer would buy up all 120 million lbs, because the monopsonist still earns a net profit of $2/lb. Since it could no longer push the farmgate price lower, it would buy up the entire quantity available.

Monopsonistic buyers need to take into account the difference of short-run and long-run supply curves of the producing countries. In the short run, with a given planting of coffee, supply curves are highly inelastic. It may be possible to drive down the purchase price of the coffee without reducing the supply on offer. In that case, the monopsonist can drive farmgate prices down considerably. Yet the longer-term supply response will be much higher. Farmers will shift from coffee to other crops. The monopsonist will not be able to buy the desired quantities in the future. For this reason, monopsonistic buying power should be exercised with great discretion, taking into account longer-term implications of low supply prices.

There is probably little monopsonistic power vis-à-vis Brazil's high-tech producers since their supply elasticity is quite high. It is therefore unlikely that market power explains much of the decline in prices facing Brazil's high-productivity sector. Still, with the recent decline in prices during 2018 and 2019 corresponding with the increased concentration of roasting-retail in the hands of Nestlé and JAB Holding Company, we do not rule out the possibility of some monopsonistic downward pressure on prices even regarding Brazilian high-productivity coffee. It is possible, for example, that the major buyers are pushing down prices excessively without taking into account the long-term negative consequences on supply even in Brazil.

It may also be true that coffee producers in the rest of the world are facing increased monopsonistic pressures. If this is the case, we would see a decline in farmgate prices faced by ROW producers relative to the farmgate prices paid to Brazil's high-productive farmers. We do not have the detailed evidence necessary to determine if any such price differential has recently occurred.

If this is in fact the case – that farmers outside of Brazil have suffered a larger decline in quality-adjusted prices than have Brazil's farmers – one remedy would be to institute minimum prices in the non-Brazilian markets linked to farmgate prices paid in Brazil to the high productivity sector. The minimum price could not deviate sharply from the Brazilian reference price, as that would shift purchases away from the ROW farmers towards Brazilian farmers. But if Brazil's farmers are being paid, say, $1.50 - $2.00 for mild Arabica coffee beans and farmers in other countries are receiving a lower price, then imposing a minimum price in the other markets that is linked to a Brazilian reference price would be beneficial for the ROW farmers and for global efficiency.

If the roaster-retailer has market power both on the buying side (as a monopsonist) and on the retail side, as a seller, the situation is more complicated. The markup of retail prices over farmgate prices will now include three factors: Monopsonist Power + Costs + Marketing Power. Marketing power may also be considered to be "brand power." It is partly a reflection of quality (and the associated costs and returns of R&D to produce high-quality coffee), as well as brand loyalty and advertising. In the coffee industry, it is likely that large roaster-retailers such as Nestlé and JAB Holding Company have both monopsonistic power in the producing countries, with this power being passed through to traders buying on behalf of the monopsonists, and marketing power in the consuming countries. The result is a mark-up over production costs that is often several dollars per pound. For example, a pound of high-quality branded Arabica coffee might retail for $10/lb (or higher), while the farmgate price is $2/lb and the production costs are another $3/lb, leaving the markup due to monopsony and brand power at $5/lb.

The existence of a large mark-up on the consuming side also has powerful implications for coffee producers. To the extent that coffee producers can enter the consumer market directly, for example through direct e-marketing, they will capture a larger proportion of the value added in the coffee supply chain. Of course this has been a hope and aspiration of coffee producers for a long time, but the advent of direct online marketing and e-branding/e-commerce may facilitate the entry of new producers into consumer markets (see Section IV).

To summarize the main conclusions of this section:

1. The ICA's export quotas collapsed mainly because of the excess supply of Brazil's efficient producers.
2. Since the collapse of the ICA's export quotas, world prices have determined mainly by the supply of Brazil's efficient producers (and to lesser extent by that of Vietnam's producers when it comes to Robusta coffee, as discussed in Section I).
3. Rising efficiency in Brazil lowers the world price and squeezes farmers that lack Brazil's efficient production.
4. Rising world demand is likely to be met primarily through increased production in Brazil, without a significant rise in world coffee prices.
5. The survival of production in the ROW will depend on raising yields in the ROW, as well as competing on quality, through more sustainably intensive production techniques, more inputs, irrigation, and improved varieties and farm techniques.
6. Increased market concentration, and hence increased monopsonistic prices especially in the ROW, may have contributed to the recent decline in world coffee prices.
7. Creating a minimum price linked to a reference price in Brazil might be workable and beneficial for ROW farmers.
8. Coffee producers should more aggressively explore options for penetrating the branded value chain through the new opportunities offered by e-commerce (discussed further in Section IV).

B. A Quantitative Assessment of the Future of Coffee Supply

The rest of this Section discusses results from a new quantitative model of coffee supply and demand. First, we consider the challenges to coffee production, and implications for coffee supply, over the next 30 years. We are particularly interested in the effects of climate change on yields: what areas will see benefits from near-term climate change, and what regions will struggle to continue to grow coffee? Although many of the changes in climate that will unfold over the next 30 years are already inevitable, any economic changes that can result from climate change are far from predetermined. We are interested in the potential for improving yields, reducing farmer risks, and helping them to adapt.

Challenges for Coffee Production

Coffee production and coffee farmers will face an array of new challenges over the next 30 years. The ability of farmers to adapt, innovate, and learn from these challenges will shape the economic stability of coffee farming, the fate of many regions' biodiversity, and the coffee varieties available to consumers. The potential applications of new technologies for mechanization and precision agriculture, and new heat- and drought-resistant varieties, will also shape farmers' prospects.

Climate change will be one of the most pervasive challenges facing farmers. Higher temperatures and other changes to the seasonal cycle will affect yields and increase the risk of coffee tree die-off. Coffee production also relies on other species in the environment, to maintain soil health and for pollination.[97] Shade-grown coffee, intercropped systems, and agroforestry systems all make the role of other species more explicit, although other species are present for all coffee production. The effects of climate change on each individual species and on the agricultural system as a whole are hard to predict and represent pervasive risks.

Warmer temperatures will also increase the risks of coffee diseases. Hotter conditions have influenced the spread of coffee rust[98] to altitudes that were once free of the fungus. Such conditions have also been shown to increase the reproductive cycle of coffee berry and white stem borers.[99] More farmers may switch to cultivating Robusta coffee as a result, with losses both for coffee quality and to farmers who will earn less for their work.

Climate change will also change rainfall patterns and make them more variable. Storms will become more intense and damaging, while dry periods will become longer. This will also undermine the potential for irrigation. Ensuring a consistent water supply through irrigation is one of the most effective ways to adapt to higher temperatures,[100] but, in the future, water supplies for many regions will become less reliable.

Climate change will also have a direct effect on coffee quality.[101] The highest quality coffees are generally grown at high elevations, because these cooler temperatures slow coffee fruit growth and allow flavors to develop. Higher temperatures, as well as higher CO2 levels, will cause coffee fruits to mature more quickly, resulting in a less flavorful product.

Finally, warmer temperatures will have a direct effect on farmers, as well as on their workers. Outdoor work in tropical areas can be dangerous on hot days, particularly for the aging coffee farmer population. Small increases on top of existing high temperatures can have a large effect on farmer and farmworker health[102] and labor productivity[103]. This will be compounded by water and food security challenges that climate change will exacerbate in some regions.

Some of the challenges of the next 30 years are not new, but their interactions are important to understand. The persistence of low prices paid to farmers make it difficult for them to make the investments necessary to adapt to climate change. Low prices and extreme events are likely to drive further consolidation in coffee production, both geographically and into larger plantations. These changes, in turn, will increase the costs of smaller farmers outside of these consolidated regions to get their coffee to markets. All of these effects can contribute to poverty for smallholder farmers.

Another sustainability challenge in the coffee sector emerges from the responses of farmers to these changes. As some coffee-producing areas become less productive, there will be a greater demand to expand into natural land, impacting biodiversity.[104] The increasing use of pesticides, fungicides, and fertilizer may also seep into the surrounding environment and disrupt it. New irrigation systems, if not properly managed, will draw water away from environmental needs. Responding to these sustainability challenges requires a comprehensive approach.

1. Our Approach

As part of this report, we develop models that represent some of the most important economic, environmental, and adaptation changes that will challenge the industry in the next 30 years. These models are aimed at helping us to anticipate long-term changes in supply and demand relations in the coming decades. Many of the opportunities and challenges facing the industry will emerge from the long-term tendencies regarding supply and demand relations, and their effects on long-term world prices for coffee.

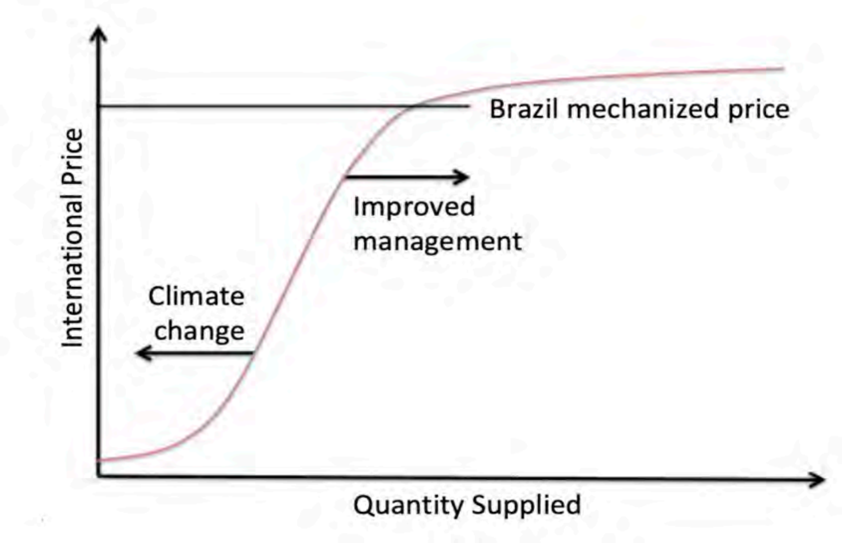
First, we discuss the insights of the coffee supply model, which represents the behaviors and outcomes of farmers in response to prices, weather, and suitability. This model is the basis for our coffee production estimates and supply-demand interactions below.

The approach taken here is global, quantitative, and largely physical. This means that our supply analysis considers the role of farmers as they affect yield and economic suitability, but does not analyze other important aspects of farmer welfare, including employment opportunities, health, social services, and direct consequences of climate change on farming families through heat waves and extreme events.

We pay special attention to the differences between regions. Coffee production in different areas shows different kinds of sensitivity, depending on the varieties of coffee grown and details of local costs and management. First, throughout the analyses, we distinguish between Arabica coffee, which has a higher quality but is generally more sensitive to environmental conditions, and Robusta coffee, which has a less favorable taste profile, a higher caffeine content, and is less susceptible to disease. We also estimate different parameters of our model in every region, to reflect different varieties within these species, to the extent that the data allow.

Figure 19: Simplified Coffee Supply Curve.

Depending on the changing state of climate and management practices, both the total amount and spatial distribution of coffee production across the globe will shift.



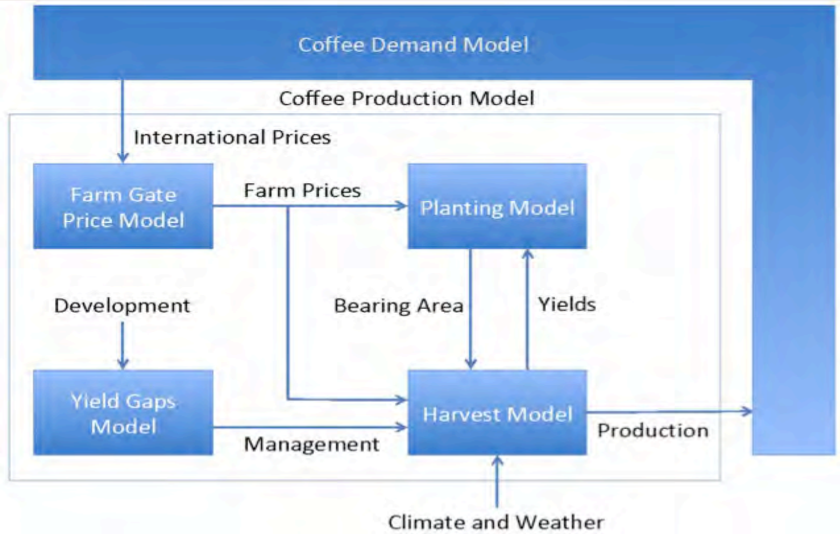
A number of important aspects of coffee production are largely implicit in our model. We do not explicitly model coffee diseases, although these are likely to expand under climate change and we capture their historical trends within our yield model. Similarly, coffee bean quality is not studied here, but we estimate different prices for coffee according to region and species.

A simplified representation of the resulting supply curve is shown in Figure 19. At any price level, the curve represents the quantity of Arabica or Robusta coffee available, and where it is produced. However, this curve is not static, and depends upon pre-existing coffee planting, coffee tree ages, and grower experience. Over time, as climate changes, coffee-producing areas will need to shift, and many current coffee areas will become ecologically unsuitable for high-quality coffee. Simultaneously, improved cultivars, management techniques, and automation will increase coffee supply.

This curve can only be estimated by developing high-resolution estimates of coffee productivity and suitability.

Figure 20: Diagram of the Major Components of the Coffee Supply Model.

Models for Farm Gate Prices, Planting Decisions, Yield Gaps, and Harvests, are described below.



The model developed for this project is represented in Figure 20. All of the model components are grounded in data; some also represent coffee biology, economic theory, and farmer dynamics. In each year, coffee production responds to the prices from the previous year.

The components of the coffee supply model are described briefly below, with more details in the appendices.

The **Farm Gate Price Model** is an econometric model, which predicts farm gate prices from international prices, underlying trends, and records of differentials. This model is estimated from annual World Bank international coffee prices for Arabica and Robusta coffee, and prices paid to producers collected by the ICO. Records of differentials are used to estimate a simple model of how regional production levels can demand price premiums, and were provided by Lavazza.

The **Planting Model** represents the decision for farmers to expand land under cultivation or switch to or out of coffee production. It uses farm prices and yields as inputs to determine whether positive profits are inducing more coffee production. While there is an enormous variation in observed decisions to change planted area at the regional level, we find that revenues, as a combination of prices and yields, predict the general direction of these changes. It also accounts for the ability of some countries, most notably Brazil, to vastly expand their production. The model produces an estimate of the area of coffee farms that is currently harvestable (the "bearing area"), based on past planting.

The **Harvest Model** includes both the biological model, which estimates yields as a function of weather, and the harvesting decisions of farmers. Yields depend upon several features of the growing conditions within each season, including minimum and peak temperatures, the distribution of rainfall, humidity, and sunshine. The Harvest Model uses these to predict yields at a high resolution. Depending on these yield levels and labor costs, farmers then make harvesting decisions, obscuring the true biological yields. The model uses a Bayesian approach to simultaneously estimate the hidden biological yields and farmer adaptation practices.

The **Yield Gaps Model** captures the relationship between model parameters in the harvest model and suitability, as estimated by the Global Agro-ecological Zone (GAEZ) project. The model parameters are the result of both ecological suitability and management practices, such as irrigation and input use. We relate GAEZ suitability, which reflects surveyed management practices, to develop model parameters in areas of the world that are not well-represented in our data. This also allows us to model the opportunity to close yield gaps through investing in new management practices, by describing the corresponding change to model parameters.

Future predictions: The process for predicting coffee production in the future and its responses to changes in prices and climate uses all four models. We use projections of future climate from the state-of-the-art MIROC-ESM-CHEM climate model under a business-as-usual (RCP 8.5) scenario. In each year from 2017 to 2030, we translate predicted international prices into farmgate prices, and combine them with local projected weather to estimate yields using the Harvest Model. These predicted yields are then used to determine if farmers expand or reduce coffee areas, which determines the conditions for the next year. Under some scenarios, we also model investments taken to close yield gaps, as well as assumptions about expansion into new areas. The combined estimated global coffee production is fed into the Coffee Demand Model to estimate the next year's international prices.

In the sub-sections below, we first discuss changes in climate that have already occurred and will occur by 2050 (sub-section 2). In sub-section 3, we present the sensitivity of coffee yields to climate, and changes in these yields that are predicted to occur over the next 30 years. These yield changes will then affect regional planting decisions, which we explore in sub-section 4. Finally, sub-section 5 discusses the opportunities to close yield gaps and adapt to climate change with improved management.

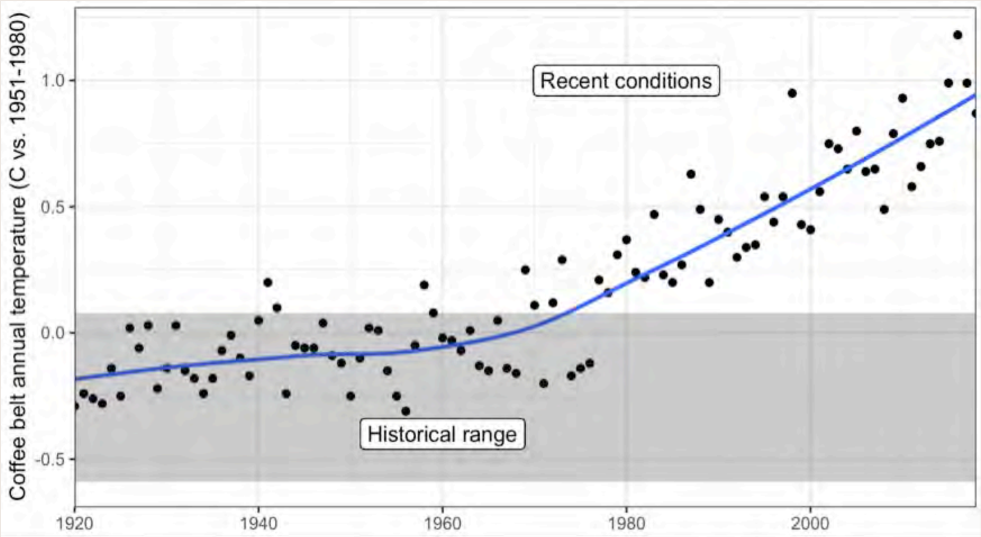


Figure 21: Annual Average Temperatures Over Land in the Coffee Belt.

Data from GISTEMP.[129]

2. Changing Climate

The coffee belt[105] has already experienced a significant shift in temperatures, and that shift becomes more extreme every year. The average annual land temperature of the coffee belt is now about 1.5 °C higher than its pre-industrial average, and continuing to increase. Figure 21 reports temperatures relative to the 1951 - 1980 average, which was already 0.5 °C warmer than the preindustrial average. Temperatures have increased at a rate of about 0.2 °C per decade since 1970, and the rate is increasing. This warming is driving several other changes that affect coffee. Although all times of the year are getting warmer, the range of temperatures throughout the year is growing wider as hot months get even hotter. Total rainfall is increasing, but becoming less useful for agriculture: wet months are getting wetter and dry months are getting drier with more intense but less frequent downpours.[106]

Different parts of the coffee belt are subject to different amounts of warming (Figure 22). In the Americas, much of the coffee heartland in southern Brazil and Guatemala has already warmed 2 °C above pre-industrial temperatures, while Colombia remains cooler.[107] The largest increases in temperature in Africa are in non-coffee-producing regions, and Uganda in particular has avoided most of the warming in our data, but with higher rates reported elsewhere.[108] Across southern Asia, coffee-growing areas in India and Vietnam have warmed by 1 °C, but much of Indonesia has experienced less change.

By 2050, few places in the tropics will have experienced less than 1 °C of warming, and the average warming over the coffee belt will be 2.8 °C. Almost 20% of the coffee belt will have warmed by more than 4 °C, which represents the limit of warming that can be offset by shade grown cultivation.

More importantly, the range of average temperatures across the coffee belt no longer overlaps with its historical range, and it has not overlapped it since the 1980s. This is clear both at an average level across the tropics in Figure 21, and for the historical range of temperatures in individual regions. Over the last 20 years, the average location in the tropics was at the 94th percentile of its historical temperature range, and most regions were experiencing 1-in-10 year temperatures every other year. Currently, the only major coffee-growing region that is far outside of its historical temperature range is southern Brazil. By 2050, only 10% of the tropics will be below the 99th percentile of their historical range; in other words, the normal annual temperatures in 90% of the tropics will fall into what were historically classified as 1-in-

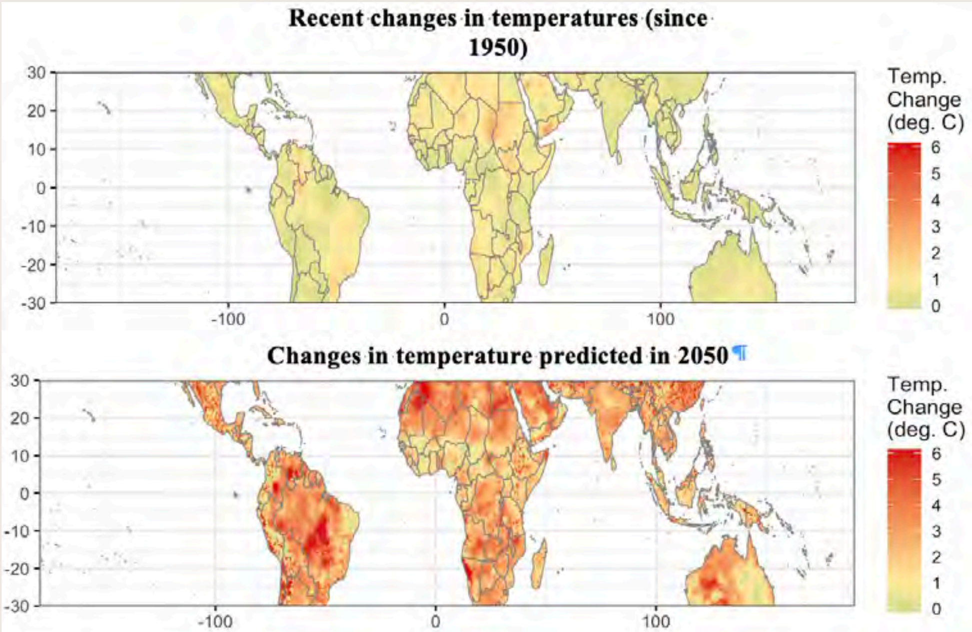


Figure 22: Changes in Climatic Temperature Already Experienced as of 2010 in the Coffee Belt (Top) and Those Predicted by 2050 (Bottom) Under a Business-As-Usual Scenario.

Existing changes are measured by station observations[130] from 1999 - 2018, relative to their average before 1950, and future predictions use the MIROC-ESM-CHEM global climate model.[131]

100 year heat events. These shifts are shown in Figure 23. The exceptions are parts of Colombia, Honduras, and eastern Indonesia. The consequences of such a fundamental shift are difficult to predict, and certainly of concern.

All of these changes are predicted to continue to occur with high confidence. In this report, we use a "business-as-usual" climate scenario, which assumes that strong, global climate policies will remain out of reach. The first successes of the Paris Agreement, falling costs of renewables, and growing agitation for a green transition all offer hope that we will diverge from this pathway long before 2050. However, the past 20 years of inaction on climate have made most of the warming between now and 2050 inevitable. It is prudent to prepare for

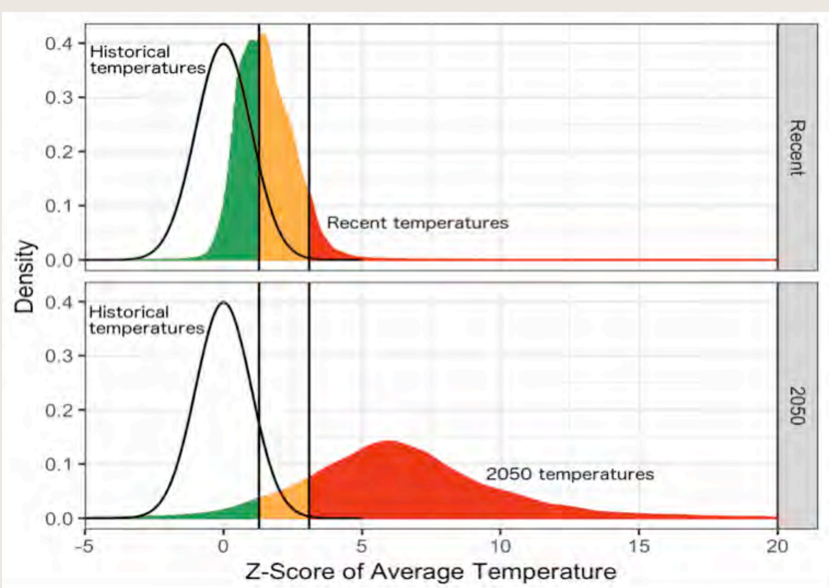


Figure 23: The Distribution of Average (Climatic) Temperatures in 1999 to 2018 (Top) and Around 2050 Under a Business-As-Usual Scenario (Bottom).

The distribution of temperatures historically is shown with a black curve, and is calculated using observed temperatures from 1900 to 1960, as normalized using z-scores. That is, all temperatures in the figure are reported in terms of their difference from their historical mean for each region, in units of the standard deviation of their historical temperatures. Yellow portions of the distribution are above the 90th percentile of historical temperatures, while red portions are above the 99th percentile.

climate changes from a business-as-usual scenario, because near-term actual changes cannot be much less extreme than these.

Shifting Suitability

Coffee is highly sensitive to climate, and grown in areas where climate change could rapidly drive lands out of these narrow suitability envelops. As temperatures increase, coffee production will be forced toward the poles and to higher elevations. If warming continues at its current rate, with an average increase of 0.2 °C per decade, coffee production will need to shift an average of 58 km per decade toward the poles or 37 m higher per decade. Under the warming expected around mid-century (2-2.5 °C globally), the minimum altitude suitable for coffee production in Central America and Kenya is expected to increase by around 400 m.[109]

In the next 30 years, the GAEZ suitability dataset suggests that 75% of available, unforested land suitable for Arabica farming will be lost due to climate change, and 63% of similarly suitable land for Robusta farming. However, there is vastly more suitable land available than currently in use by coffee, and this fact will remain under near-term climate change: over 9 times as much land is estimated to be suitable for Arabica production globally in 2050 than the total of land currently under its cultivation. The largest pool of available coffee land remains in Brazil, despite considerable losses.

At the same time, the land currently being used by coffee farmers in many regions will become unsuitable economically. Even allowing for coffee farming to shift within countries, 14% of land currently under Arabica cultivation is at risk of becoming economically unsuitable. As shown in Figures 24 and 25, the portion of coffee area at risk varies greatly across countries.

These shifts are a problem both for smallholder farmers and the coffee industry as a whole. While coffee production as a whole can shift, smallholder farmers are unlikely to migrate. Most affected smallholder farmers will leave coffee production, resulting in losses of coffee farming knowledge, physical and institutional capital, and the productive trees themselves.

At the level of the coffee industry, two concerns are worth highlighting. First, the loss of these farmers will drive further consolidation, undermining a diverse coffee market. Second, these farmers have knowledge and expertise that could take decades to recover.

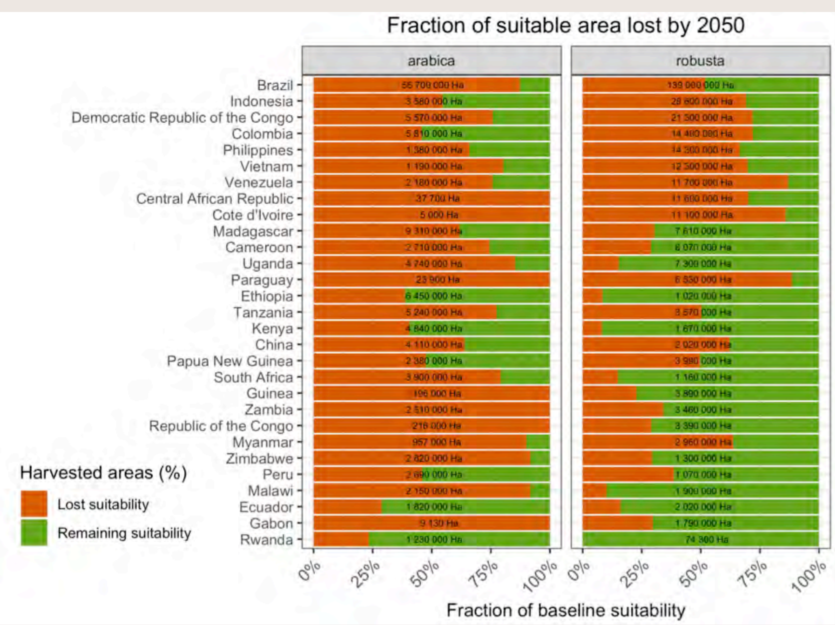


Figure 24: Portion of Currently Suitable Area Projected to Become Unsuitable Due to Climate Change.

The red bar shows the percent of suitable area lost, and the green bar shows the portion that remains economically suitable. Values exclude forested land and wetlands.

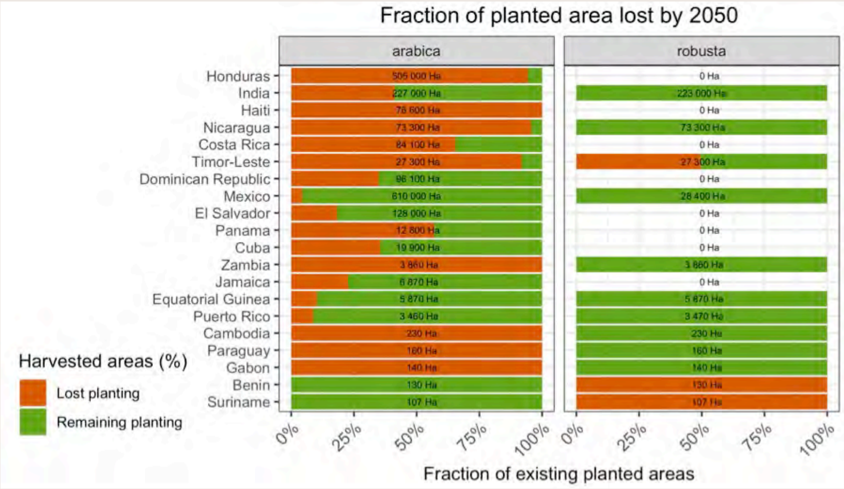


Figure 25: The Portion of Suitable Land Currently Under Cultivation Lost Due to Climate Change, for Affected Countries.

The total currently cultivated land is represented by the full range of each bar (in some cases approximated by an even division between Arabica and Robusta, where data is unavailable). The red portion represents how the shortage of suitable land across the whole country can force reductions in planted area, even allowing for movement within countries.

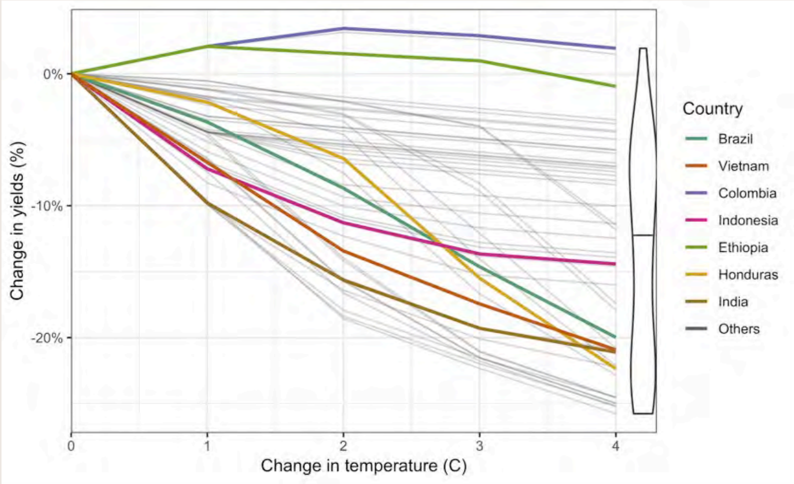


Figure 26: Changes in Average Yields as a Function of Temperature Increases.

These changes are applied to weather in 2017. The violin plot on the right shows the distribution of changes under 4 °C warming.

3. Changes in Coffee Yields

We develop a statistical approach to predicting the future of coffee yields. This work builds upon advanced approaches that combine a biologically-motivated representation of moderate and extreme temperatures[110] and account for the potential for adaptation.[111] However, as a perennial tree-crop, coffee is much more complicated than the field crops that these methods were first developed to model. We need to account for the period before seedlings can produce coffee berries, the yield of different ages of the trees, and the maintenance required. Farmers play an important role in mediating the relationship between coffee trees and climate, and we develop our model to account for that.

As temperatures increase, not all regions will be impacted identically. Depending on the specifics of climate change that each region is subject to, and the specifics of management practices, we predict different changes, as shown in Figure 26. After 2 °C of warming, all regions show decreases in yield, but Colombia and Ethiopia see increases prior to that point. This is explained by the beneficial effects of moderate temperatures in the coffee-growing areas of those countries. At 4 °C, yields on average fall by over 10%, and many major coffee-producing regions, including Vietnam, India, and Honduras, experience losses in excess of 25%.

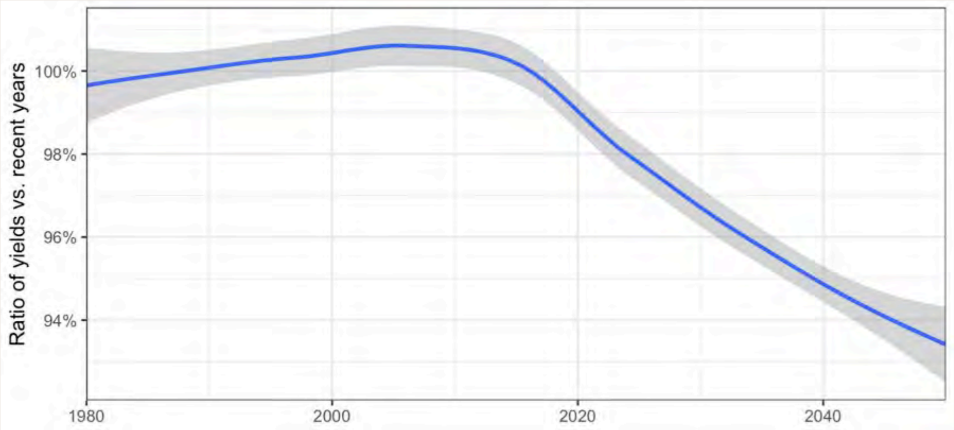


Figure 27: Average Loss in Yields Due to Climate Change, Through 2050.

We project losses to reach about 7% by 2050.

As a global average across production, these losses will start hitting soon and will increase rapidly (see Figure 27). These losses can be offset by improvements in management (discussed in sub-section 5), but without such improvements, they will already be noticeable by 2020.

4. Changes in Planted Area

As demand increases and yields fall, prices for coffee will increase slightly. Higher prices will incentivize farmers to expand their coffee production, particularly in Brazil where there are low barriers to reclaiming land previously used for coffee production. Although the literature on the response of farm planting to prices is quite old,[112] researchers have generally not integrated it with more recent work on crop yields. Taken alone, prices are not a very good predictor for changes in coffee planted area. However, when combined with yields to form an estimate of farmer revenue, there is a clearer relationship (see appendix). Farmers with higher yields are more likely to expand under price increases than those with lower yields.

Our model shows that, under recent prices from 2018, held constant into the future, most countries decrease their land under cultivation because of low current prices and falling yields. Nine countries leave coffee production entirely, although these only account for 2% of current production. Of the large producers, India is projected to have the greatest decreases in planted area. Ethiopia is projected to increase its Arabica planted area, and Vietnam is projected to increase both Arabica and Robusta production (see Figure 28).

The combined effect of these changes is predicted to be a 13% decrease in planted area globally (see Figure 29). However, it is important to note that this analysis assumes constant prices for coffee. As a result of both lower yields and reduced areas, lower total coffee production may raise prices slightly, due to the increased scarcity of coffee. These higher prices will induce some farmers to plant more than predicted here. However, the ease of increasing production in some countries, such as Brazil, will keep the effect of climate change on prices small for the next few decades.

Figure 28: Changes in Planted Area, in Response to Current Prices.

A baseline year of 2013 is used, and data on planted area up to 2018 is used where available.

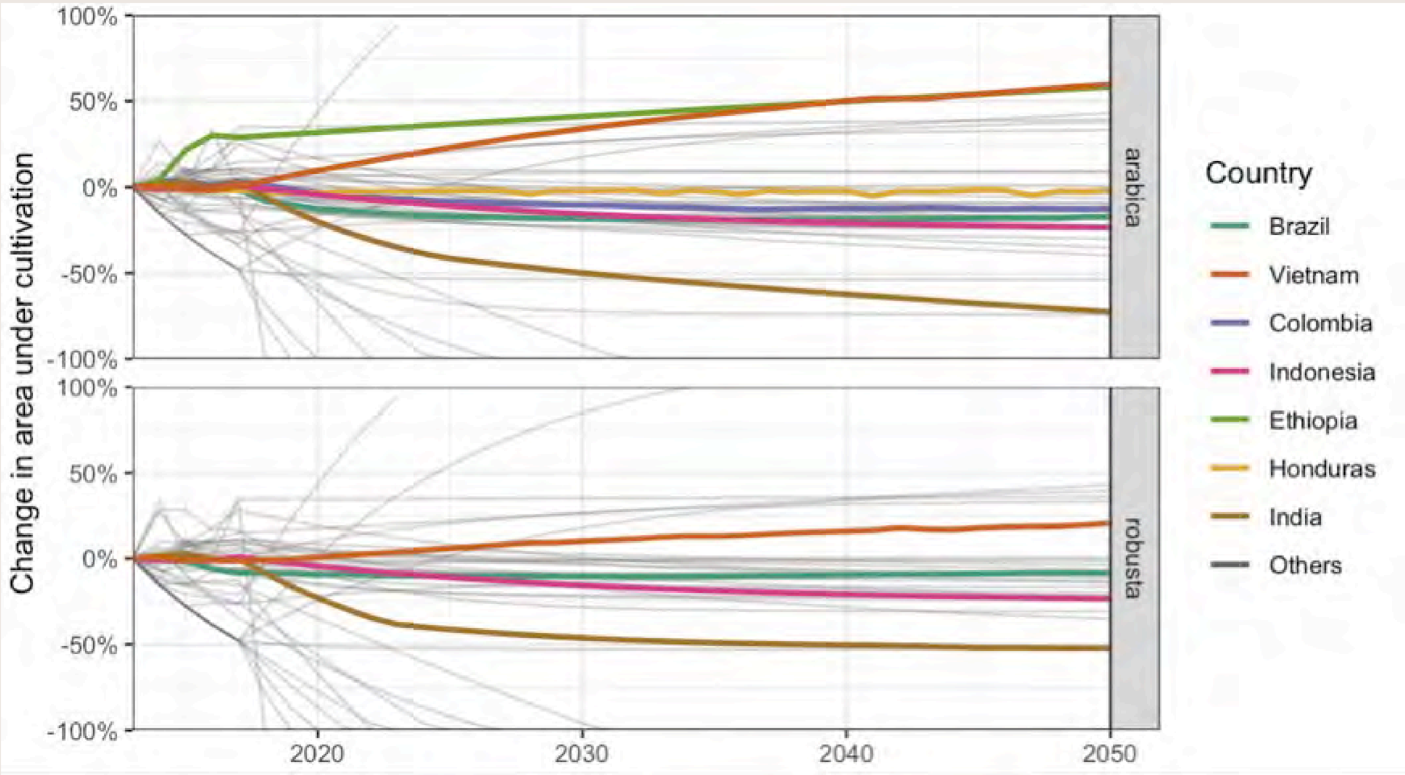
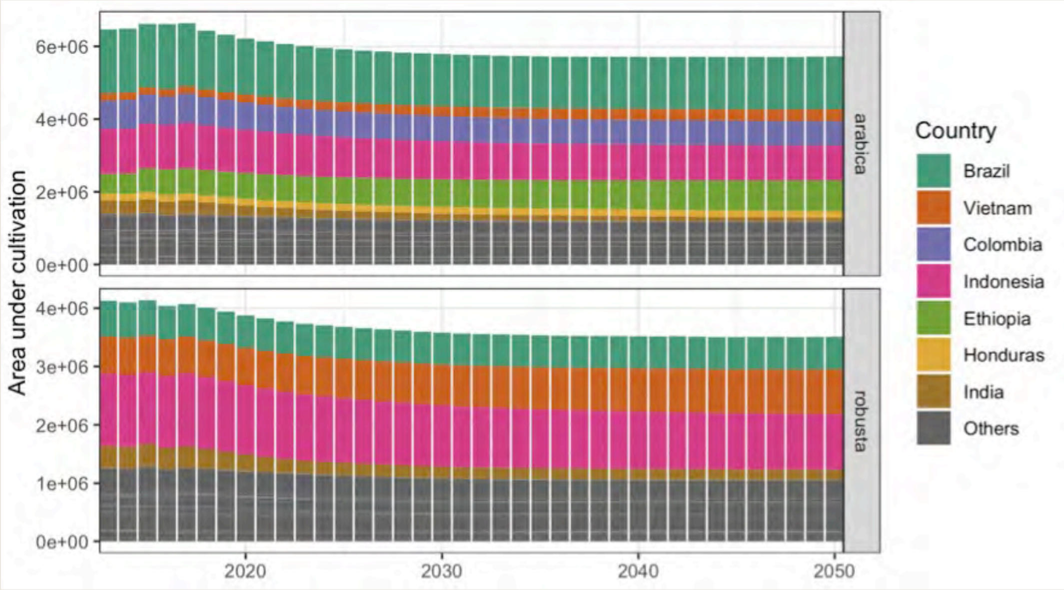


Figure 29: Evolution of Planted Area by Country to 2050.

Prices are held constant at 2017 levels.



5. Opportunities to Close Yield Gaps

Baseline Future Projections

In Figure 30, we show forecasts of production, split by country, under constant prices. In Figure 30, we also do not include the continuation of historical yield increases, to isolate the relative effect of climate. Arabica production ceases to climb, and falls gradually by 10% over the next 30 years due to climate change, in the absence of improvements in management. Robusta production increases, driven by additions from Vietnam, but also does not follow its previous trend.

Considerable increases in production are possible, if prices increase. The predicted supply curve, as a function of prices, is shown in Figure 31. As an indication of the responsiveness to prices, a doubling of price results in a 30% more Robusta production by 2030, but only 15% more Arabica production over the same time. The majority of supply increases come from large producers that are highly responsive to changes in prices—in particular, Brazil and Vietnam. Although the increase in Brazilian production at higher prices is not as extreme as described in Section II(a), the predicted effect is the same: at any level of prices, Brazil can increase production to take advantage of almost all of the additional demand. At higher prices, production continues to climb through 2040, as more trees come to maturity. However, this long delay also affects the potential for production to quickly shift in the near term. When we look at the effect of higher prices on 2020, rather than 2030, Arabica production is almost entirely unaffected by increased prices, and Robusta production only increases slightly. Countries are, however, responsive to lower prices, and will abandon coffee production if prices continue to fall.

Figure 30: Projected Production for Arabica (Top) and Robusta (Bottom), in Terms of Dried Beans.

The continued variation in production after 2025 is driven by a natural cycle as harvests are adjusted to follow prices and respond to demand.

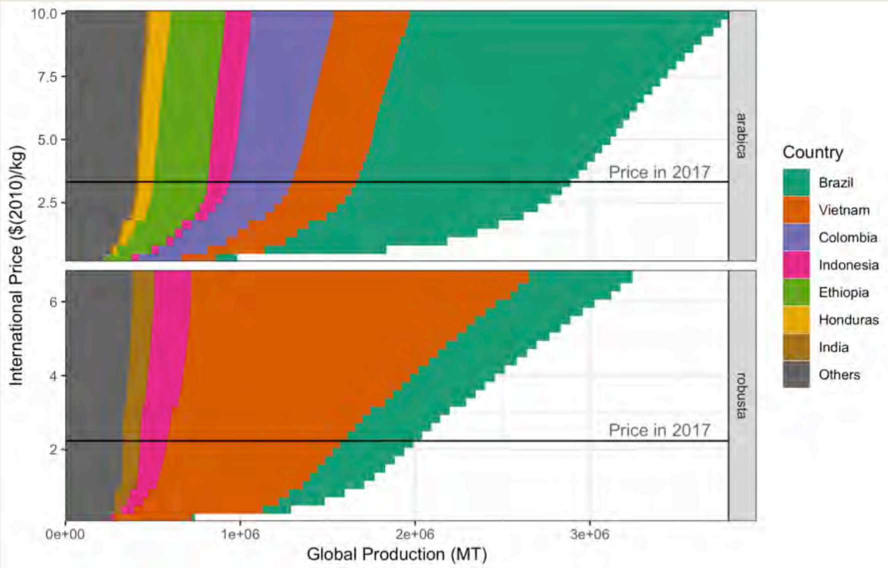


Figure 31: Supply Curves for Arabica and Robusta, as a Function of International Price Changes.

Colors split the supply by country. Results are evaluated in 2030. The larger share of production in Vietnam reflects continuing yield trends, which we did not apply in Figure 30, but which are included here.

Yield Gaps

Enormous disparities exist between the yields typical of different parts of the world (see Figure 32). The countries at the 75th percentile in yield have over 3 times the yields of those at the 25th percentile. If yields globally could be brought to the yield levels in Brazil, which makes widespread use of fertilizer and irrigation, global production would increase by 70%.

Using our model, we can project improvements in yield that could result from the large-scale investment of countries in improved management. In particular, we look at the potential of increased use of fertilizer and irrigation (see Figure 33). Most countries see the greatest benefit from irrigation, with Ethiopia increasing Arabica yields by 22% and Indonesia and Honduras increasing yields by 14%. Fertilizer also has potential for increasing yields, although in some cases we cannot distinguish these effects from irrigation (e.g., Ethiopia and Indonesia), and in many cases the potential is more modest (< 5%), except in the case of India, which is estimated to have over 10% increases in yield.

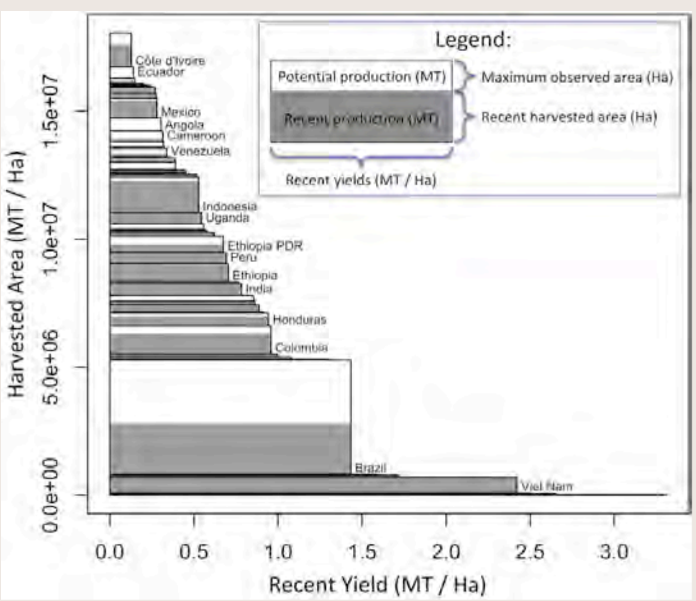
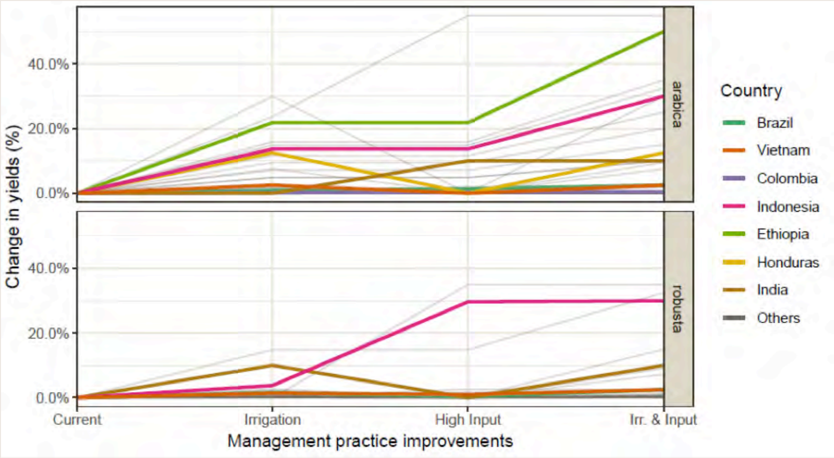


Figure 32: Observed Yields (X-Axis) and Harvested Area (Y-Axis), by Country.

Since production is the product of yield and harvested area, the area of each box is proportional to the production of the country. Only some boxes are labeled, in each case at the base of that country's box.

Figure 33: Percent Increases in Yields That Could Occur Through the Application of Country-Wide Irrigation and Input Measures.

The changes are estimated by considering potential increases in GAEZ suitability of the main coffee-growing area, and then normalized to match results from USAID.[132]



We apply these improvements globally, while keeping planted area the same, to understand the potential for increasing production by closing yield gaps. Total Arabica production could increase by 18%, and Robusta production by 16%, under the high range of yield gap potential. This represents a total of an additional 770,000 MT, about the production of Colombia. These productivity improvements would be shared across many producing countries, with the greatest potential in currently under-performing countries.

Some countries have considerable opportunities to improve yields, such as Ethiopia, Peru, Papua New Guinea, and Uganda. These opportunities require multiple investments: in irrigation systems, inputs like fertilizers and pesticides, more effort in tree care, and in many cases, the replanting of old trees.[113]

Figure 34: Estimated Production if Development Practices are Fully Adopted.

The effects of development improvements upon yields are applied uniformly within each country.

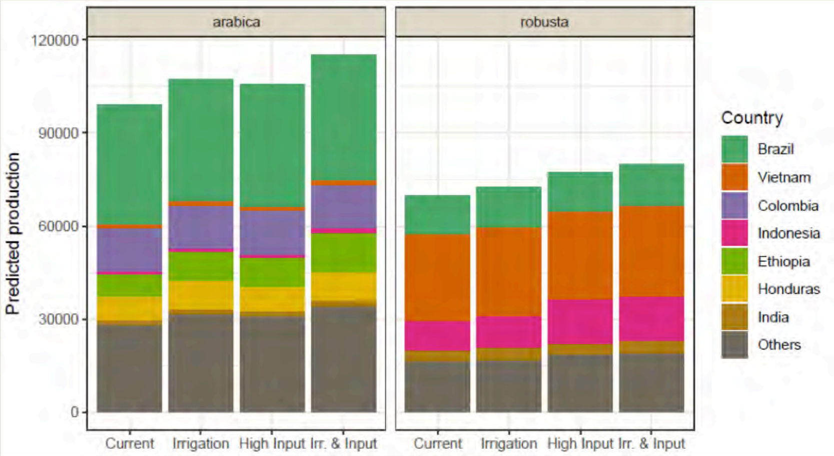


Table 1: Improvements in Production, by Country and Management Practice

Country	Variety	Production (MT)	Inputs	Irrigation	Irr. & Inputs	
Arabica Improvements						
Brazil	arabica	1155000.00	<3%	<2%	<6%	(USAID[1])
Colombia	arabica	414750.00	<1%	<1%	<2%	(USAID[1])
Honduras	arabica	228000.00		5 - 20%	5 - 20%	(USAID[1])
Ethiopia	arabica	211650.00	9 - 35%	9 - 35%	19 - 80%	(USAID[2])
Peru	arabica	131250.00	4 - 19%	4 - 19%	10 - 40%	(USAID[2])
Mexico	arabica	116250.00	2 - 8%	2 - 8%	5 - 15%	(USAID[2])
Guatemala	arabica	108000.00	2 - 12%	2 - 12%	5 - 25%	(USAID[2])
Nicaragua	arabica	81000.00		5 - 11%	5 - 11%	(USAID[1])
India	arabica	47490.00	5 - 15%		5 - 15%	(USAID[1])
Costa Rica	arabica	45000.00		10 - 50%	10 - 50%	(USAID[1])
Vietnam	arabica	39000.00		<6%	<6%	(USAID[1])
Indonesia	arabica	30000.00	4 - 23%	4 - 23%	10 - 50%	(USAID[2])
Papua New Guinea	arabica	22800.00	19 - 90%	8 - 39%	19 - 90%	(USAID[1])
Uganda	arabica	22500.00	7 - 25%	7 - 25%	14 - 56%	(USAID[2])
Kenya	arabica	21450.00	4 - 15%	4 - 15%	10 - 31%	(USAID[2])
El Salvador	arabica	19500.00	2 - 8%	2 - 8%	5 - 15%	(USAID[2])
Tanzania	arabica	18000.00	7 - 23%	7 - 23%	14 - 50%	(USAID[2])
Myanmar	arabica	4273.00	<1%	<1%	<1%	
Yemen	arabica	3750.00	<4%		<4%	
Puerto Rico	arabica	1934.00	<2%		<5%	
Congo	arabica	1598.50	<1%		<1%	
Cameroon	arabica	1500.00	<1%		<1%	
Madagascar	arabica	750.00	<1%	<3%	<4%	
Dominica	arabica	143.50	<1%		<1%	
Comoros	arabica	70.00	<1%		<1%	
Mauritius	arabica	25.00	<1%		<4%	
Robusta Improvements						
Country	Variety	Production (MT)	Inputs	Irrigation	Irr. & Inputs	
Vietnam	robusta	840000.00	<3%	<3%	<6%	(USAID[1])
Brazil	robusta	372000.00	<1%	<4%	<6%	(USAID[1])
Indonesia	robusta	282000.00	9 - 50%	1 - 7%	10 - 50%	(USAID[1])
India	robusta	110490.00	<1%	4 - 15%	5 - 15%	(USAID[1])
Uganda	robusta	108000.00	14 - 56%		14 - 56%	(USAID[1])
Malaysia	robusta	63000.00	<1%	<1%	<1%	
Tanzania	robusta	16500.00	7 - 23%	7 - 23%	14 - 50%	(USAID[2])
Cameroon	robusta	14100.00	<1%	<5%	<5%	
Madagascar	robusta	6750.00	<1%		<1%	
Guinea	robusta	5700.00		<4%	3 - 16%	
Guatemala	robusta	5400.00		<4%	5 - 25%	(USAID[1])
Myanmar	robusta	4273.00		<1%	<2%	
Puerto Rico	robusta	1934.00		<1%	<3%	
Sierra Leone	robusta	1650.00		<1%	<1%	
Congo	robusta	1598.50	<1%	<4%	<5%	
Nicaragua	robusta	750.00		<1%	<1%	
Angola	robusta	570.00		<3%	2 - 12%	
Liberia	robusta	420.00	<1%	<3%	1 - 5%	
Cambodia	robusta	182.50		<1%	<1%	
Dominica	robusta	143.50	<1%	<1%	<5%	
Comoros	robusta	70.00	<1%	<1%	<1%	
Belize	robusta	40.00	<3%	<2%	<4%	
Mauritius	robusta	25.00	<1%	<1%	<2%	

[1]: Values corrected to conform to USAID potential.
[2]: USAID potential used, and divided evenly between fertilizer and irrigation.

Opportunities to Expand Production

Another insight in Figure 31 is that many countries are not using the full area for coffee production that they historically had. Returning cultivation to these areas could increase total production by an additional 60%, if yields were to remain constant, without causing coffee to expand into new areas.

Table 2: Total Available Land that is Highly Suitable for Arabica and Robusta, and the Highest Level of Suitability for Each Found in the Country

Suitability levels are reported by GAEZ as between 0 and 100%, and we consider highly suitable land to be >80% for Arabica and >90% for Robusta.

	Arabica		Robusta	
Country	Area (km^2)	Max (%)	Area (km^2)	Max (%)
Argentina	4200	88	0	78
Australia	2500	82	9900	100
Bolivia	9800	85	213900	100
Brazil	321600	87	2660100	100
China	135100	90	26600	100
Cameroon	2000	83	229000	100
DRC	7900	83	1717100	100
Colombia	20600	84	133700	100
Costa Rica	500	83	16700	98
Dominican Republic	2900	84	16000	100
Ecuador	5300	84	3400	94
Ethiopia	22000	83	0	87
Guatemala	3400	82	31100	99
Honduras	400	81	36500	100
Indonesia	1100	82	108000	100
India	52600	89	65500	98
Kenya	32600	84	0	76
Laos	21900	86	150600	99
Sri Lanka	200	81	14200	100
Madagascar	126100	86	59600	100
Mexico	23200	86	70800	100
Myanmar	81700	90	143600	98
Mozambique	8400	87	100	90
New Caledonia	700	81	7500	100
Peru	24100	85	169900	100
Philippines	1100	82	68000	100
Papua New Guinea	500	83	29300	100
Rwanda	4600	83	0	76
Swaziland	11000	88	0	64
Thailand	200	81	43600	99
Taiwan	1900	87	4500	98
Tanzania	10700	84	18300	100
Uganda	3400	83	9700	100
USA	200	83	6100	100
Venezuela	5000	84	169000	100
Vietnam	7100	88	129200	100
South Africa	18600	89	0	74
Zimbabwe	4000	87	0	46

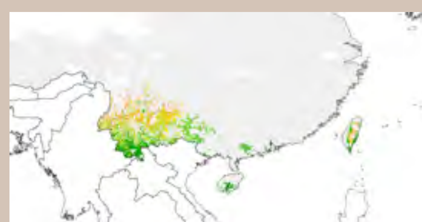
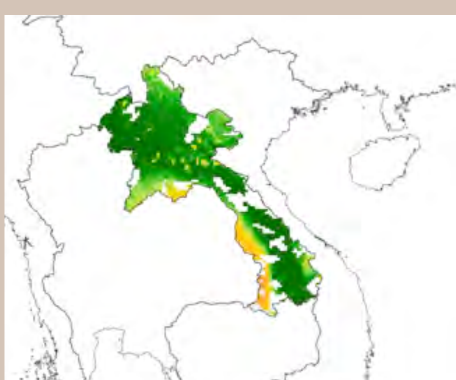
From a suitability perspective, many countries have more land that is suitable for coffee production than is currently under cultivation. The area that is highly suitable for Arabica and Robusta coffee for each country is listed in Table 2.

These highly suitable areas depend only upon the biological and climatological conditions within each region, and do not require irrigation or additional fertilizer inputs. We also report the highest level of suitability for each coffee species, which ranges from 0 – 100%. Areas that are highly suitable for coffee have the potential to produce high quality coffee at yields comparable to the most competitive regions. However, the ultimate potential for any region depends upon a variety of other constraints, including labor availability, the ease of machinery use in the landscape, transportation infrastructure and access to markets, and suitable seed varieties.

We can consider the potential of China and Laos as a case study, as shown in Table 3. Currently, almost all of the area of Laos is potentially suitable for Robusta coffee; however, the area that will remain suitable in the future will diminish. The Yunnan province in China has considerable potential as well, and unlike Laos, this potential will increase as temperatures warm. These suitability estimates should be treated with care, as the climatologic data is uncertain in many of these regions.

Table 3: Baseline and Future Suitability for China and Laos

Baseline suitability is evaluated at the current temperatures, with no irrigation or fertilizer inputs. Future irrigation is evaluated in 2050, with advanced management practices. All maps have protected areas removed, with suitability and protected area data from GAEZ.

Immediate Opportunities (Low-Input, Rain-Fed, Baseline)	Mid-Century Opportunities (High-Input, Irrigated, 2050)	
		China's coffee growing potential will grow over the course of the century, particularly in Yunnan province. Hainan is productive now, but will fade.
		Laos has considerable coffee production potential, mainly for Robusta coffee. Many of the lower-lying areas, however, will experience yield losses over the next 30 years, so investment choices should be made carefully.

C. Future Prospects

To assess future prospects, we developed a coffee demand model based on projections of income and population growth. The relationship between coffee demand and prices is highly variable across countries.[114]

A summary measure of the responsiveness of demand to prices is price elasticity. This is the portion of a change in prices that translates into a change in demand. For example, a price elasticity of -0.5 means that if prices increase by 10%, demand will reduce by 5%. We find that Arabica coffee has a global price elasticity of -0.08 and Robusta coffee has an elasticity of -0.15. These values imply that demand is extremely inelastic, reflecting the apparent low sensitivity of consumers to price changes. However, the responsiveness to prices is not identical everywhere. Elasticities vary from over -0.09 (Japan) to below -0.075 (Germany) for Arabica coffee. The comparatively narrow range for these may reflect a real similarity in how countries respond to prices, or may be the result of the noisy and limited data available for the analysis (see annex 4).

The demand curves are also determined by growing income (according to an income elasticity of demand) and population growth. The demand curves, across all countries, are shown in Figure 35, below.

Combining the two models for supply and demand allows us to understand how the market equilibrium affects both producers and consumers. As demand continues to climb and more regions experience losses from climate change, prices will begin to recover. However, this increase is likely to be modest, because the higher prices will incentivize more production, particularly Brazil's mechanized production. Importantly, the most responsive farmers are those that are able to produce coffee most cheaply, and these will be able to keep up with the increased demand for the foreseeable future.

The figure below shows the predicted change in prices, under two scenarios: "business-as-usual" and "closing yield gaps" (See Figure 36). The business-as-usual scenario is based on Brazil and Vietnam's continued dominance when it comes to productivity growth, resulting in greater concentration in production. This productivity growth keeps prices for Arabica coffee low, although growing demand increases them by about $1/kg by 2030. Increases in Robusta coffee consumption boost its prices somewhat, and Robusta coffee production approaches Arabica coffee levels.

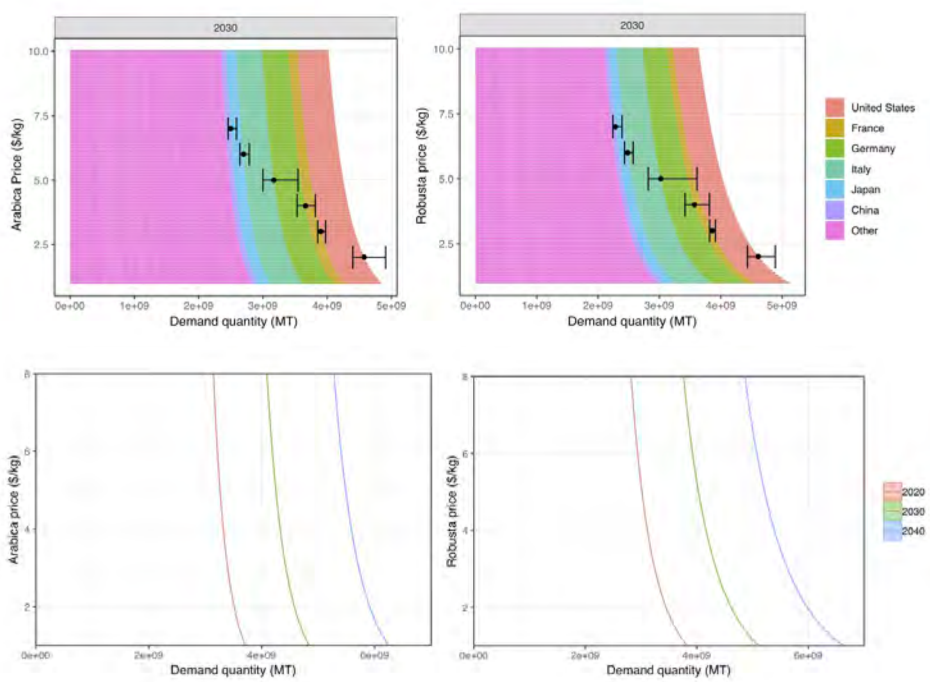
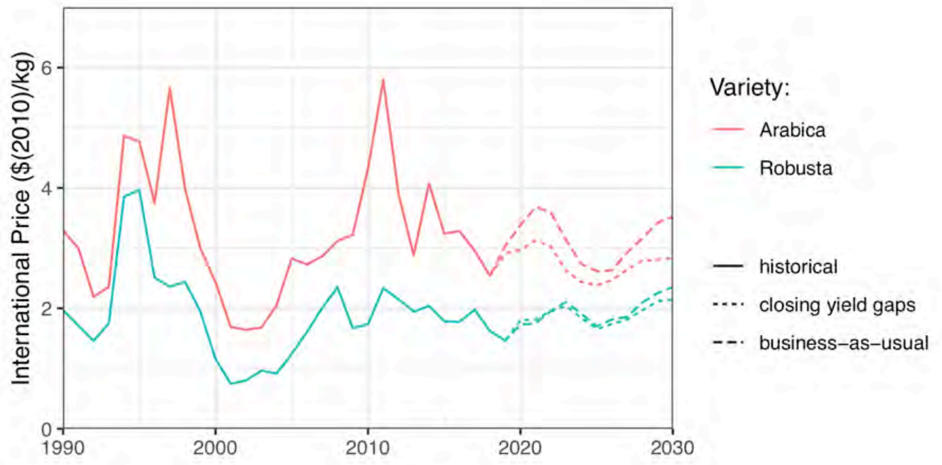


Figure 35: Demand Curves in 2030 (Top) and Showing the Growth Globally Across 2020, 2030, and 2040 (Bottom).

Error bars show the 90% confidence intervals for each country's curve. The greater demand in later years is the result of increases in income and populations.

**Figure 36:
Business-As-Usual vs
Closing-Yield-Gaps Scenario
Prices**



Under the closing-yield-gaps scenario, we allow countries to close yield gaps to the extent described in the previous section. Productivity gains are then more distributed, which decreases Vietnam and Brazil's domination of the market. However, the increased global production resulting from closing yield gaps also depresses prices below the level of the business-as-usual scenario. Most countries see greater benefits from the higher yields than they lose from lower prices, and as a result show increases in production. Brazil and Vietnam produce less coffee relative to the business-as-usual case, because these countries are more responsive to prices and have less to gain from closing yield gaps. In addition to the benefits of higher yields to offset lower prices, any comprehensive plan for sustainable development should include support for incomes, prices, or diversification, to ensure that all producers see benefits from the increased production.

In addition to the effects resulting from closing yield gaps, the persistence of low levels of prices under the closing-yield-gaps scenario is explained by a combination of factors. First, we assume that yields continue to improve as they have in recent years. This effect is notably strong for Vietnam yields, which increase, even as total production in Vietnam is depressed under the closing-yield-gaps scenario relative to the business-as-usual scenario. In the absence of this assumption, prices rise by about $1/kg by 2030 in the closing-yield-gaps scenario. Second, we assume that countries and regions that previously used more land for coffee production can easily increase their land use in response to higher prices. This is particularly relevant for Brazil, which previously had very large amounts of land under coffee cultivation. However, this increase in farming takes a few years of higher prices to take effect (see appendix), resulting in Arabica coffee prices that rise slightly to 2022, and then drop back down.

This report is particularly concerned with the potential losses of coffee variety and producer livelihoods over the next decade. Under the business-as-usual scenario, while the increased demand helps some countries, there are several that see significant decreases in production, particularly India and Malaysia. Total production increases by 26%, of which 76% is accounted for by Vietnam and Brazil (see figure 37). Under the closing-yield-gaps scenario, many of the same countries experience decreases, but the decreases are smaller overall, and the increases are less concentrated in Brazil and Vietnam. Total production increases by 29%, of which 64% comes from Vietnam and Brazil. This highlights the need for countries that have smaller market shares to maintain competitiveness if their varieties are to be sustained. This competitiveness will require raising the value per hectare that farmers receive, which entails, to various degrees, both improving quality and improving yields.

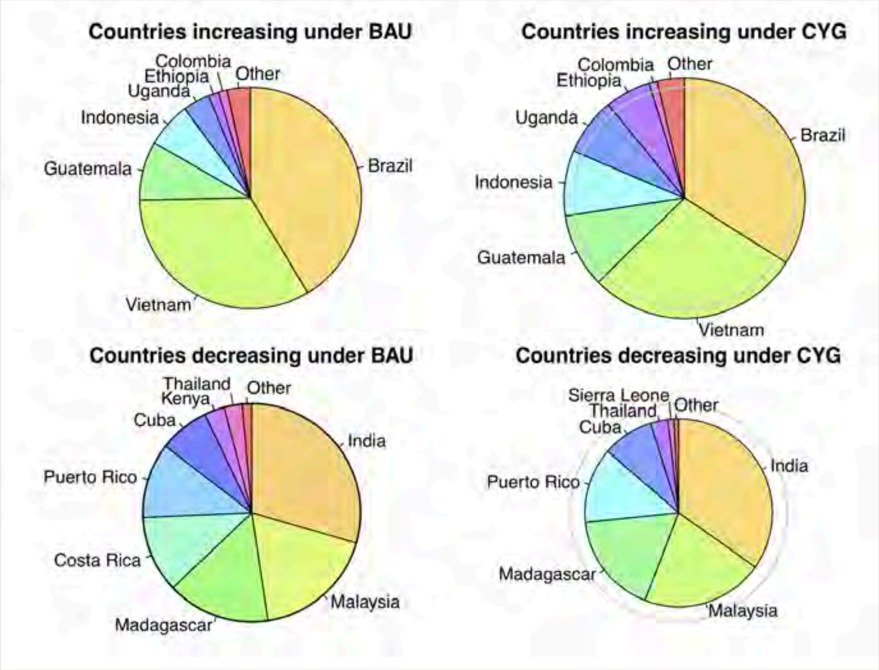
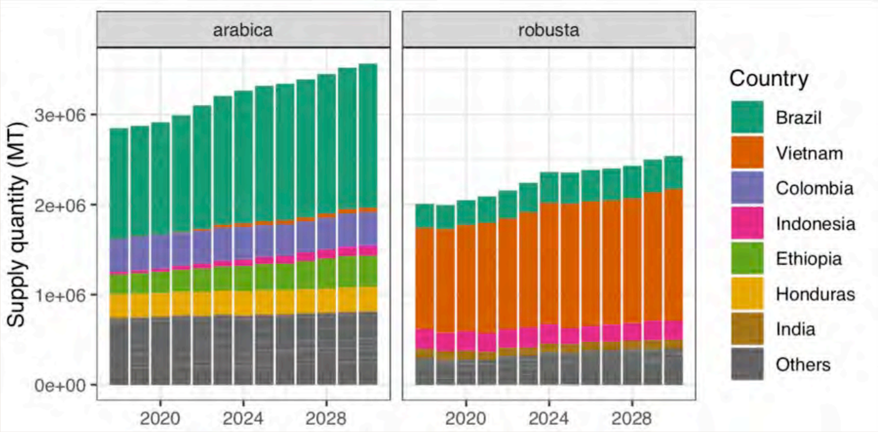


Figure 37: Shifts in Production Under Business-As-Usual (BAU) and Closing-Yield-Gaps (CYG) Scenarios By 2030.

The values in the pie charts are the portion of the global increases (top) and decreases (bottom) in production quantity that occur within each country. Total BAU increases in increasing countries are 1.2 million MT, and decreases in decreasing countries are 29,500 MT. The area of the Closing-Yield-Gap pie charts are scaled relative to the BAU charts, and the size of the BAU chart is shown as a grey circle on the right. Countries representing greater than 1% of the increases/decreases are labeled.

Figure 38: Closing Yield Gaps Scenario: Supply



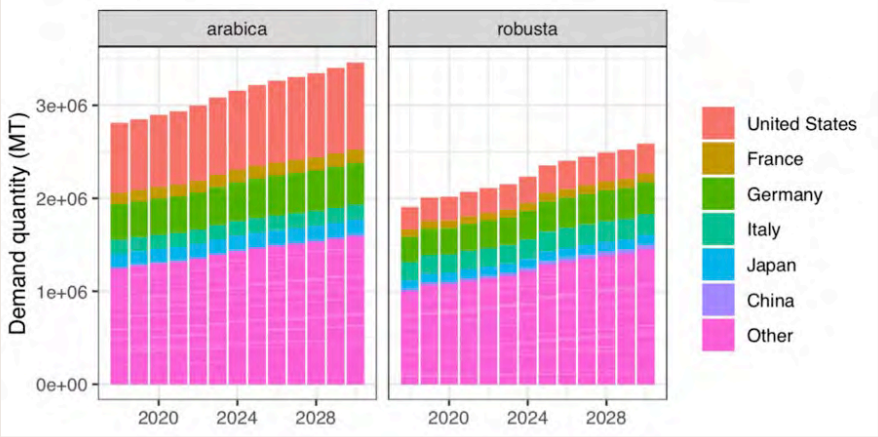


Figure 39: Closing Yield Gaps Scenario: Demand

Closing Yield Gaps Scenario

Below we further explore the closing-yield-gaps scenario, and its consequences for supply and demand through 2030. Between now and 2030, total production increases steadily, but the increases are uneven across countries (see Figure 38).

On the demand side, the consuming countries that currently dominate the coffee market show very little change, while emerging markets represent the greatest driver of the coffee industry's growth. This reflects emerging markets' growing incomes and purchasing power. Under the business-as-usual scenario, higher prices result in slightly lower consumption than in the closing-yield-gaps scenario.The baseline demand scenario is driven by population and income growth. Several other factors are emerging in the coffee market that may alter demand:

1) Accelerated demand growth from East Asian and coffee-producing countries. According to the ICO, coffee consumption in East Asia (India, Indonesia, the Philippines, Vietnam, China, the Republic of Korea, and Taiwan) has grown at an accelerated annual rate of 6% in the last 25 years. The region's share in global coffee consumption has grown from 5% to 12%. The highest growth rates are for China (12%), Vietnam (10%), and Taiwan (10%).[115] In addition, consumption is expected to grow in several coffee-producing countries, due to urbanization and policies to encourage domestic coffee consumption. Brazil,[116] Colombia,[117] and Uganda,[118] for example, have implemented policies to incentivize increased coffee consumption at home. In an alternative demand growth scenario for East Asian and coffee-producing countries, an annual growth rate of 10%[119] was used. The emerging demand from East Asia and from producing countries is expected to have a bigger impact on consumption of Robusta coffee than Arabica coffee. This is because Robusta coffee is associated with lower prices, which makes it more appealing in low- and middle-income countries.[120]

2) The improvement of technology enables Arabica coffee and Robusta coffee blends to taste similar to a 100% Arabica coffee.121 This trend has the potential to decrease Arabica coffee demand and increase Robusta coffee demand. As there is a lack of data and studies that assess the potential impact of this trend, this alternative demand scenario was not formally tested in the model.

3) There is growing demand for capsules and pods in developed economies. The sales of coffee capsules and pods represents 11% of the world sales of coffee today[122] and is expected to grow by a CAGR of 7% in the near future.[123] While capsules and pods sell at a premium, the amount of coffee used in each capsule is lower than in traditional coffee-making processes. For capsules, only 5-7 grams[124] of coffee is needed per cup,[125] while filter/drip coffee requires 10-15 grams[126] per cup. Capsules therefore have the potential to reduce the amount of coffee needed by up to 50%. Using this assumption, an alternative demand scenario was modelled, which foresees a market share for capsules (consuming half of green beans as compared to wholesale/ground coffee) growing to 23% of total Arabica coffee demand in 2026 and remaining constant thereafter (from a baseline of 17% in 2017).

4) Consumption per capita in developed countries might be increasing, driven by the growth of specialty coffee, which encourages higher coffee consumption in some markets.127 Thus one alternative demand scenario considers an additional annual growth of 1.5% on top of the baseline.

Figure 40, below, shows the difference in demand by 2030 resulting from testing the above outlined alternative demand growth scenarios. The first three bar charts show the results for each of these scenarios separately. The last bar chart combines them.

In our model, the demand resulting from these combined factors would moderately increase global prices because supply, even from Brazil, will not be able to keep up with demand at a constant price, but there remains uncertainty as to whether each demand growth factor will materialize. The greatest increase in demand comes from the developed country assumptions in this combined demand-factor scenario, because of their high baseline level of demand. The effects of higher demand growth rates amongst producer countries and East Asian countries are fairly minor until after 2025. Capsules, which are assumed to increase their market share by 23% of the total market, have a large impact on the price of Arabica coffee, so that the gap between the combined factor demand scenario and the closing-yield-gaps scenario is much larger for Robusta coffee prices.

D. Discussion of the Model Results

Understanding the challenges and opportunities of coffee production requires sophisticated models which can account both for economic decision-making and for environmental changes. This is relevant for coffee yields and production, where farmers make important decisions about maintenance and harvesting, as well as for coffee demand, which responds to prices and changing tastes.

There are considerable differences between regions and varieties in terms of their production potential and how they respond to climate and changing prices. On average, Arabica coffee is more sensitive to rising temperatures, and producers of Arabica coffee respond more slowly to prices. Over the next 30 years, 14 – 34% of land currently under coffee cultivation is at risk of becoming economically unproductive. While there remains plentiful land for coffee production across the tropics, ensuring that the movement of coffee does not result in land grabbing or deforestation is an important challenge. Meanwhile, the growing productivity of coffee in Brazil and Vietnam could result in greater concentration of coffee production there, putting many specialty varieties at risk.

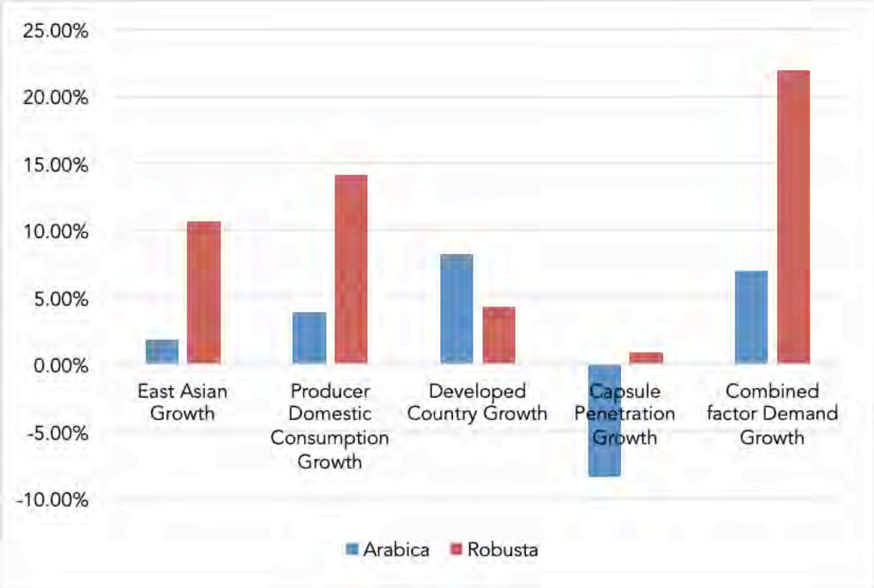
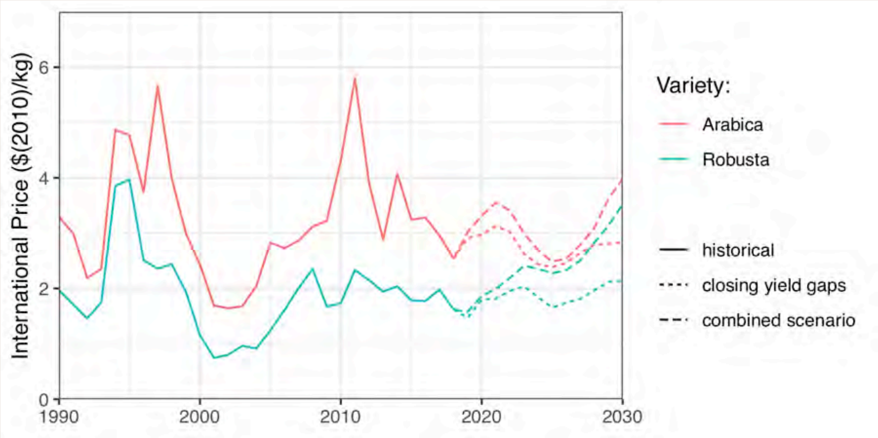


Figure 40: 2030 Change in Closing-Yield-Gaps Scenario Demand as Compared to Baseline (In %)

Figure 41: Impact of the Combined Factors of Demand Growth on Long Term Prices (Closing Yield Gaps Scenario)



Smallholder farmers are particularly vulnerable. They have the fewest resources to adapt to climate change, and temporary economic or environmental shocks can force them out of coffee farming. There are about 12.5 million coffee farmers,[128] most of whom are smallholders, and ensuring a stable livelihood for these smallholder farmers, in coffee or out, is an important development priority. Low prices also hit these farmers the hardest, and under current prices, we predict most countries to decrease their land under coffee cultivation, and some countries to cease coffee production entirely.

New resources are needed to inform smallholders, as well as other producers, about the risks they face, and to help them improve their management practices to be productive, resilient, and profitable. Providing these kinds of services requires resources, trained helpers, and new science. Research centers like Cenicafé in Colombia have an important role to play, by developing new disease-resistant and heat-resistant varieties, supporting tree renovation, and providing or supporting extension services. In particular, coffee farmers everywhere are in need of "climate services," which help them to manage their risks and potential under climate change. These services include information on new varieties and management practices, and how these practices can protect them under more frequent weather and disease risks. In some areas, they will need to understand the potential changes in coffee suitability, to help inform the long-term decisions that are necessary for coffee farming. On a season-by-season basis, there is also important information available on expected weather, since many regions are heavily affected by climate patterns like El Niño and La Niña, which are predictable months in advance. Finally, greater variability should not be a barrier to areas that continue to be productive in most years, and expanding the availability of crop insurance programs (see Box 9) can greatly help farmers endure occasional shocks. The needs for new resources and services for smallholders and other producers could be met the multi-stakeholder undertaking that we present in Section IV. Such investment would also support greater sustainability within the coffee sector generally. In the following section, we discuss what coffee sustainability entails—including the economic sustainability of producers—and review some of the sustainability efforts undertaken in the coffee sector to date.

III. Coffee Sustainability

A. Coffee Sustainability and the Sustainable Development Goals

Sustainability has three components: environmental, social, and economic.[133] **Environmental sustainability** encompasses two broad issues: the continued availability of resilient ecosystem services, and the maintenance of conserved nature. More broadly, it requires climate resiliency. **Social sustainability** considers impacts on people. This includes the avoidance of harms—no child labor, no land grabbing—as well as positive steps, such as increasing food security. **Economic sustainability** focuses on the ability of producers and farmworkers to earn sufficiently from their respective roles in coffee production to live a life with dignity. This component, which has presented some of the most intractable sustainability challenges, and which has been urgently highlighted by the World Coffee Producers Forum since its inception in 2017,[134] is discussed further in box 2.

These three sustainability components are overlapping, and are often mutually supportive. For example, improved economic sustainability in the form of higher earnings for coffee farmers can help alleviate or avoid social sustainability issues, such as child labor and food insecurity. Stronger environmental sustainability practices, such as the incorporation of cover crops in some locations, can help make some farmers more resilient to the impacts of climate change, thereby supporting their longer-term economic sustainability.

The Sustainable Development Goals provide a specific framework for integrating sustainability within the coffee sector, and for supporting sustainable development in coffee-growing regions. Aligning coffee with the SDGs presents a clear goal for upstream and downstream actors along the value chain.[135]

While nearly all of the 17 SDGs hold some relevance for the coffee sector, 14 of them are particularly relevant, and can help to provide substantive goals for the coffee industry and for governments of coffee-producing countries. These SDGs are, in brief:

- **No Poverty (SDG 1).** Particularly—but not only—at times of low global coffee prices, poverty persists amongst coffee producers and farmworkers. Coffee prices are currently 32% below the average of the last ten years, following a general downward trend since 2016,[136] resulting in a steady erosion of many coffee farmers' abilities to achieve a decent livelihood. Finding ways to eradicate, or at least significantly reduce, the poverty that stalks those who are providing the raw ingredient at the heart of the $200 billion industry[137] will be critical for the coffee sector to align with the SDGs. This includes finding new models for increased producer profitability (see Section IV) and, potentially, providing social protection through income support transfers for the poorest farmers (see Box 7). Efforts to reduce producer poverty can also include strategies such as increasing their tenure security and documentation of land rights, per SDG Indicator 1.4.[138]

Photo by Tina Guina on Unsplash

Box 2: Economic Sustainability Within the Coffee Sector

For coffee producers, economic sustainability requires, at a minimum, that coffee production be economically viable over the long-term.[184] Producers who are planting below a minimum threshold of hectarage may never be economically viable, as it is nearly impossible to avoid poverty when landholdings are too small.[185] For those above that threshold, economic viability is possible, although very difficult when global prices are extremely low.

Economic viability can be considered the minimum core of economic sustainability. Going beyond viability, economic sustainability should also consider producers' earnings and whether those earnings are sufficient compensation for their unpaid labor.[186] This is at the core of the "living income" concept, which has been defined as "[t]he net annual income required for a household in a particular place to afford a decent standard of living for all members of that household."[187] This decent standard of living encompasses elements such as food, housing, education, and healthcare.[188]

The concept of living income recognizes that household income can come from multiple sources.[189] This aligns with the realities of many producers, for whom diversification, including to non-coffee crops and to off-farm work, can supplement income and/or limit risk. Such diversification can also be important as a means of climate adaptation.[190] A recognition of the realities around, and importance of, diversification does not mean, however, that diversification should distract from the challenges of making coffee production itself more economically sustainable for producers.

In very low price environments, the economic sustainability component of coffee production at a global scale might primarily be achieved either through changes in pricing mechanisms, or through income supplementation, as discussed further below. There is also a role for promoting increased farmer profitability at the individual and association levels, whether through increased productivity, efficiency, and/or quality, depending on individual contexts and market opportunities. Yet the benefits that farmers in many countries might realize from increased productivity or efficiency will still be constrained during periods of sustained low prices.

For farmworkers, economic sustainability requires decent work[191] and adequate "living wages."[192] A living wage is a wage that is "sufficient to afford a decent standard of living for the worker and her or his family."[193] Minimum wage laws covering farmworkers generally do not require a living wage, and the vast majority of farmworkers working in coffee—and in all other agricultural commodities, in any country—do not earn living wages. For economic sustainability to be a reality in coffee production, farmworker earnings will have to increase. Yet increased wages for farmworkers could drastically increase costs of production, thus placing producers' own economic viability at risk—unless prices are high enough to cover both decent earnings for producers and decent wages for their workers.

Particularly when prices are low, the challenges of achieving economic sustainability in the coffee sector are enormous. Of course, these challenges also go beyond coffee. They mirror challenges found in other agricultural commodities, even in highly developed economies, as well as general economic development challenges of rural areas in low- and middle-income countries.

Nonetheless, the various considerations noted above, along with companies' co-responsibility for economic sustainability, imply the need for new strategies that insert more equity within coffee global value chains, including those discussed below in Section IV.

\

- **Zero Hunger and Sustainable Agricultural Production (SDG 2).** Hunger, food insecurity, and malnutrition often go hand-in-hand with poverty. For many coffee farmers, who harvest coffee at peak times once or twice a year, hunger is cyclical, as farmers work to stretch the payment for the coffee they have sold after the last harvest as well as to stretch any staple food crops they have produced for their own consumption. In Latin America, farmers have described these periods in which they struggle to consistently feed their families as "the thin months."[139] Achieving SDG 2 in coffee thus implies supporting farmers and their families to avoid this seasonal hunger, including through supporting higher incomes from coffee as well as other strategies, such as diversification.[140] In addition, the targets developed under SDG 2 focus on sustainable agricultural production through increased productivity, incomes, and climate resilience,[141] and through investments and initiatives that support access to, among other things, inputs, knowledge, financial services, markets, research and extension services, and rural infrastructure.[142] Improving coffee farmers' access to these goods and services, and providing more general support for increasing the productivity and profitability of farmers, is equally critical for achievement of SDG 2.
- **Good Health and Well-Being (SDG 3).** Across coffee-producing countries, significant or major challenges remain towards the achievement of SDG 3.[143] While the most pressing health concerns within each country are varied, one key commonality affecting coffee farmers, farmworkers, and coffee communities is limited access to healthcare. Amongst the top ten producing countries by volume, for example, the availability of universal health coverage is classified as a major challenge in Ethiopia, India, and Uganda.[144] Even outside of those countries, however, coffee farmers and workers can struggle to access necessary and affordable healthcare. In coffee-producing countries, improving access to healthcare will be an important aspect of achieving the SDGs, one that should be prioritized by relevant governments and their donor partners.
- **Quality Education (SDG 4).** Universal access to quality education also remains a challenge in many coffee-producing countries. In 15 of the top 20 coffee-producing countries, access to quality education remains a significant or major challenge.[145] Without this access, children in rural coffee-producing areas face a bleak future. Compounding the general lack of affordable, accessible, and quality schools are the effects of child labor, which also diminishes children's educational opportunities. Here, too, some of the issues and solutions are intricately related to poverty and earning potential—children work rather than going to school when their families need the money—as well as to the prices paid to farmers, who may be incentivized to encourage child labor as a way to lower labor costs.
- **Gender Equality (SDG 5).** Women tend to benefit less than men from the production of commodity crops tied to global value chains. Coffee is no exception. It is estimated that 70% of the labor in coffee production is performed by women, but they are only 20% of the household heads or land-owners in coffee-producing families.[146] This tendency towards exclusion of women raises inherent gender equality concerns, and can also result in other negative impacts, such as on the health and nutritional status of children.[147] Aligning with SDG 5 requires at a minimum that, whichever sustainability interventions are used, care is paid to ensure that women are also able to benefit. For example, a gender-sensitive approach to supporting increased farmer productivity might include

using women agronomists and trainers, and scheduling training sessions at times and locations that are accessible for women.[148]

- **Clean Water and Sanitation (SDG 6).** Access to clean water and sanitation is a challenge across many rural coffee-growing regions. All of the top 20 coffee-producing countries have significant or major challenges to achieving SDG 6.[149] Many coffee farmers, their families, and their communities lack sufficient access to clean water and sanitation. In addition, at the farm-level, many workers also lack access to clean water and sanitation, even though access to safe water and sanitation when working is a labor right.[150] While supporting coffee farmers' increased access to clean water has happened at a limited scale,[151] a more widespread approach is needed to scale up this access throughout coffee-growing regions. Additional efforts are also required to ensure farmworkers' consistent access to water and sanitation when working.
- **Affordable and Clean Energy (SDG 7).** Yet another challenge in many coffee-growing regions is ensuring access to affordable and clean energy, such as electricity. Only two of the top 20 coffee-producing countries are top performers in the achievement of affordable and clean energy.[152] Electrification can have significant development benefits generally, as well as for farmers and rural dwellers specifically, such as by reducing time burdens on farm families, supporting improved health outcomes when displacing unhealthier energy sources, and facilitating educational improvements.
- **Decent Work and Economic Growth (SDG 8).** Coffee is failing to provide decent work. Decreasing prices in real terms, increasing costs of production, and significantly more exposure to climate-induced shocks have combined to limit the ability of coffee to support decent livelihoods. Meanwhile, labor rights, such as the right to be paid the minimum wage, are routinely violated for coffee workers,[153] while realizing the right to collectively organize and form unions remains a broader challenge for farmworkers around the world. Moreover, as mentioned above, child labor continues to persist in coffee production. Alignment with the SDGs implies not only avenues to support better livelihood outcomes for coffee farmers, but also, importantly, the enforcement of labor laws that meet minimum international standards, and the eradication of child labor.
- **Industry, Innovation, and Infrastructure (SDG 9).** In some places, a lack of good transport infrastructure in rural coffee-producing regions has driven down the prices that smallholders can charge for their coffee at the farmgate. Limited investment in irrigation infrastructure has lowered productivity and increased farmers' climate vulnerability. Although the adoption of new technologies can help farmers increase productivity, reduce information asymmetries, and help track sustainability practices, much more needs to be done to support innovations and to harness the latest technologies to further the sustainability of the sector: for example, facilitating the use of smart phone applications, blockchain,[154] or satellite imagery to strengthen climate resiliency, reduce environmental impacts of agriculture practices, or facilitate greater productivity in support of higher incomes.

- **Responsible Consumption and Production (SDG 12).** Although responsible consumption and production is critical for achieving sustainable development within our planetary boundaries,[155] significant challenges remain for the coffee sector. At the consumption end, the increasing reliance on single-use plastics and other disposable single-use packaging (such as those used for pods and capsules) is deeply concerning. At the production end, multiple factors have facilitated unsustainable production practice in some places. Specific targeted actions throughout the value chain will be necessary to support more responsible consumption and production of coffee.
- **Climate Action (SDG 13).** In recent decades, coffee has been responsible for deforestation in important coffee-producing countries.[156] In some places, coffee production may also have been accompanied by overuse of synthetic fertilizers. Both of these activities contribute to climate change. Climate change will also create immense challenges for coffee production in areas where coffee has been historically produced. Supporting climate resilience amongst coffee producers and within the industry overall should thus be a key sustainability priority for the coffee sector. At the farmer and sub-regional levels, the appropriate responses for supporting climate resiliency are context-specific. Assessing potential climate impacts can help indicate whether farmers in specific locations are likely to require incremental adaptation, more systemic adaptation, or full transformation.[157] More generally, approaches such as supporting more widespread access to affordable insurance options could help mitigate climate-related risks for coffee farmers (see Box 9).
- **Life on Land (SDG 15).** As mentioned above, coffee production is not always environmentally sustainable. Yet incorporating more environmentally sound practices that protect life on land is critical for coffee sustainability. For the coffee sector, this encompasses two broad issues: supporting the continued availability of resilient ecosystem services through sustainable agricultural practices (e.g., efficient water use, limited chemical use, and in some areas use of permanent shade, cover crops, and ecoforestry), and maintaining conserved nature. This calls for, among other things, no deforestation, the protection of biodiversity and high conservation value areas, and efforts to ensure that any increases in coffee demand do not place additional pressures on finite natural resources, biodiversity, and the climate. As climate change disrupts more farmers, stringent policies are needed to ensure that coffee production does not shift into forests and other natural areas. Healthy co-existence with the natural environment is essential for both coffee farmers and the reputation of the coffee sector.
- **Peace, Justice, and Strong Institutions (SDG 16).** The global justice gap is estimated at 5 billion people, meaning that two-thirds of the world's population lack meaningful access to justice.[158] This justice gap includes those who live in extreme conditions of injustice, those who are unable to resolve their justice problems, and those who are excluded from opportunities that the law provides.[159] Just as access to basic services in coffee-producing regions is a critical component of achieving the SDGs in the coffee sector, so too is ensuring that people-centered justice solutions are available to coffee farmers, farmworkers, and their families, in the context of coffee-related transactions and more broadly within coffee-producing regions.[160] In addition, ensuring

public access to information is a critical component of SDG 16. For the coffee industry, integrating more transparency and traceability within their supply chains will be an important contribution towards sustainability, supporting farmers in their price negotiations (see Box 6) and enabling more robust monitoring of sustainability issues throughout supply chains.

- **Partnerships for the Goals (SDG 17).** SDG 17 provides inspiration for how relevant actors—along global value chains and more broadly within the sector—might work together to achieve the SDGs. Combined with other international instruments and soft law guidance,[161] SDG 17 also implies co-responsibility of public and private sector actors for aligning the sector with the SDGs.

Actors up and down the value chain share responsibility for aligning with the SDGs and for better integrating all three components of sustainability within the coffee industry. Upstream actors, such as producers and cooperatives, have critical roles to play in implementing sustainable practices, whether that is taking steps to improve climate resiliency or ensuring that hired laborers are paid decently. Midstream and downstream actors, such as traders, roasters, and retailers, equally have responsibility for ensuring sustainability within their supply chains, as well as within the coffee sector more generally. In other words, companies are co-responsible for advancing economic, social, and environmental sustainability within the coffee sector.

Actors outside of global value chains also have relevant obligations related to sustainability. In particular, governments have legal duties under international law, as well as commitments under the SDGs, to support the realization of the rights to food, health, water, housing, and education, among others. Certain activities—such as ensuring access to healthcare and education, or enforcing the minimum wage—remain the primary responsibility of governments. Yet that does not absolve upstream or downstream actors within the coffee industry from their responsibilities to integrate sustainability throughout the production and sale of coffee.

B. Current Sustainability Efforts in Coffee

In considering the three components of sustainability, and against the SDG Framework described above, it is clear that the coffee sector is not yet sustainable. Rampant poverty amongst producers, the use of child labor, serious climate vulnerability, and challenges in accessing basic services in coffee-growing regions paint a sobering picture of how far the sector has to go to become fully sustainable.

Today's grim reality has arisen despite sincere efforts at the industry level and from individual companies, as well as by actors within coffee-producing countries, to advance coffee sustainability. At the industry level, multiple platforms have been designed in recent years to bring together stakeholders to make coffee more sustainable. These include, for example, the Global Coffee Platform (GCP)[162] and the Sustainable Coffee Challenge (SCC),[163] which have jointly produced a sustainability framework for coffee.[164] This co-owned Sustainability Framework provides a useful starting point for transparent metrics and potential monitoring of sustainability efforts, with 15 defined intervention pathways, each with their own suggested investments, actions, and outputs, along with enabling conditions, outcomes, and impacts.[165] The framework's use as an effective monitoring tool, however, has been limited to date: although the platforms have supported some level of transparency by disclosing online sustainability commitments by companies and other entities, such disclosure does not appear to include information about whether targets have been met or are on track (see Box 3). Another joint effort focused on indicators is the Coffee Data Standard.[166] Undertaken by the GCP, the Committee on Sustainability Assessment (COSA), Rainforest Alliance, and Waterwatch Cooperative, the project has developed a set of 15 farm-level sustainability indicators, which can be integrated by supply chain actors into their reporting systems. The objective is to "establish a common language to measure sustainability."[167] This is a welcome development, as scaling up sustainability in the coffee sector has arguably been hampered by the fragmentation of efforts and limited comparability.[168] How indicators are defined, however, will determine their ultimate usefulness (see Box 3, which draws lessons from the Sustainability Framework).

Box 3: Does the Sustainability Framework Adequately Cover Economic Sustainability?

The Sustainability Framework developed jointly by the GCP and the SCC includes 15 intervention pathways to advance sustainability within the coffee sector. Each of these pathways, in turn, includes various metrics, including on relevant outputs and outcomes. Many of the pathways are relevant for supporting farmers' economic viability: for example, technical assistance, renovations, access to inputs, and access to finance, as well as some of the topics under producer country policy, standards/certification, and sourcing. Yet in terms of *outputs*, there do not appear to be any that would align with companies' co-responsibility for economic sustainability in low price environments. One of the closest *outcomes* is under standards/certification: "Improved price received for coffee exceeds cost of production." However, the "output" in that pathway does not measure company action that would necessarily lead to this outcome, as it says "Pounds of green coffee produced in compliance with a standard." As noted both above and below, a significant amount of coffee is produced but not sold under sustainability standards; a more helpful indicator would instead measure company purchases of certified products, such as "pounds *purchased* in compliance with a standard," or even "percentage of supply certified." Similarly, two outcomes for the "sourcing" pathway and the "consumer country policy" pathway are "Improved prices received for coffee" and "Increased purchases of sustainable coffee in markets." Yet those pathways also do not include specific outputs that translate into actions that roasters or retailers would take to reliably lead to those outcomes.

These various sustainability platforms, and the shared Sustainability Framework developed by the GCP and the SCC, represent critical steps towards an industry-wide approach to advancing sustainability. Collaborative and joined up efforts amongst companies, on a precompetitive basis, and in partnership with civil society, will be crucial for achieving sustainability within the sector. However, the multiplicity of these platforms risks undermining their ability to achieve their sustainability goals. Continued sustained coordination amongst all of the relevant platforms, along with other ways to reduce fragmentation—including, potentially, mergers of relevant platforms or initiatives—would help mitigate the challenges inherent in a fragmented landscape of initiatives, and should be seriously explored.[169]

Apart from these global-level multi-stakeholder platforms and initiatives, other collective efforts, both at international and at local levels, are underway to advance coffee sustainability. While too numerous to list here, one is the World Coffee Producers Forum, which has helped to catalyze dialogue on, and the search for solutions to address, producers' economic sustainability during the recent price crisis. In addition, two interesting examples of *precompetitive* efforts to advance the public goods necessary for building a more sustainable coffee sector are the Farmfit Fund (and related Farmfit Business Support Facility) and World Coffee Research, described in Boxes 4 and 5, respectively. These latter two examples highlight the potential for corporate leadership and precompetitive collective action to help propel the coffee sector, and smallholder agriculture more generally, towards a more sustainable future.

Box 4: IDH Farmfit Fund

The €100 million IDH Farmfit Fund, launched in November 2018, is a blended finance investment vehicle, developed to increase investment in smallholder farmers.[194] The IDH Farmfit Fund has received private investment from Jacobs DE, Mondelez, Unilever, and Rabobank, public support from the Dutch Government, and public support from the U.S. Government in the form of guarantees from USAID.

The Farmfit Fund sponsors big projects at scale, working with specialized service providers (such as NGOs like TechnoServe and One Acre Fund), cooperatives, global commodity traders, and local commercial businesses. These partner organizations offer services to smallholder farmers, such as loans and training. These services aim to facilitate greater profitability of farmers through, for example, increased agricultural productivity and efficiency. (Although service delivery can improve smallholder farmers' incomes from their very low baseline, their incomes are often still below national median incomes even after engagement interventions.)[195]

The Farmfit Fund is designed to help assume the risk in smallholder financial transactions, making it easier for banks to loan to smallholder farmers. Because some service delivery models with high upfront costs are cost-efficient in the long-term,[196] the funding strategies for Farmfit Fund projects can change over time. During pilots, for example, a service package may use grant support to provide concessional loans. After a pilot, a service package may still be considered high risk, but may obtain access to funds from a development finance institution. As projects mature, concessional loans can be phased out as projects become independent, using their own revenue to pay back loans and gain access to commercial banks.[197] For their part, farmers or farmer organizations often have to pay back loans or pay service fees to access service delivery models: the loans are sometimes paid directly through crop yields.[198] If a service delivery model is financially sustainable, there should be net profitability in the long term for farmers, service providers, and investors.[199]

Box 5: World Coffee Research

World Coffee Research (WCR) specializes in the study of coffee plant genetics and varietals. Its agricultural research aims to support advanced agricultural science for producers around the world,[200] and to ensure a robust future supply of coffee despite climate, disease, and quality challenges. In doing so, its work can help to support producer resiliency as well as greater origin diversity of coffee through scientific analysis that will enhance production choices. Such a WCR study is currently underway in 23 countries, measuring how local and new varietals interact with different environments and growing conditions. While this work is less necessary in countries with robust agronomic research focused on coffee, it may be critical for supplementing research and knowledge in other countries.

WCR is funded primarily by coffee companies,[201] some of which contribute on a per pound basis for every pound of green coffee purchased. Through this precompetitive collective effort, WCR is able to support the development of public goods that are critical to supporting farmer wellbeing around the world, as well as the future health of the coffee industry.

Beyond these collective efforts, various certification schemes, such as Fairtrade and Rainforest Alliance/UTZ, have also been used to advance sustainable practices in (parts of) the supply chains of multiple companies. Although research has shown mixed impacts of these schemes on different measures of sustainability,[170] some certification schemes have offered important benefits to participating producers and have shifted the conversation about what practices are acceptable in agricultural production. One broad challenge stymieing the ability of these schemes to have broader impact is simply that companies have not purchased enough of the coffee produced under such standards (see Table 4),[171] which they argue is due to low consumer demand. (Of course, nothing would stop a company from committing to source only third-party certified coffee.) Because of the relatively low purchase levels of certified coffee, producers who absorb significant costs to comply with the standards thus may struggle to recoup those costs when they are unable to find a market for their certified coffee. Another worrying trend is the potential dilution of certification standards through, essentially, a race to the bottom, particularly as the entry of the 4C standard has threatened to simply lower the bar for what can be certified as sustainable, rather than serve as a stepping stone towards better and more stringent standards.[172]

Roasters and retailers have also undertaken more individualized efforts to integrate sustainability measures within their own supply chains. While some have chosen to primarily rely on external certification schemes, others have instead developed internal standards and verification methods,[173] such as the Starbucks C.A.F.E program and Nespresso's AAA Sustainable Quality Program. Individual efforts by companies have also included support for specific projects relevant to their supply chains; these are sometimes undertaken in partnership with non-profit organizations, and often seek to leverage donor funding as well.[174] At times, these individual company efforts, while targeted towards improving sustainability within their own supply chains, are not limited exclusively to them.[175]

Traders have similarly taken steps towards integrating sustainability in certain ways. While their purchase and sale of certified coffee seems to be driven primarily by client (e.g., roaster/retailer) demand, most major traders have programs at origin to support producers through trainings and technical assistance. Some also seek to support communities in coffee-growing regions more

Table 4: Percentage of Production Sold under a Sustainable Label

Certification Program	Production (tons)	Sales (tons)	% sold under standard
Fairtrade	430,000	128,000	30 %
Organic	248,767	133,163	54 %
Rainforest Alliance	265,565	129,846	49 %
UTZ Certified	715,648	188,096	26 %
AC Association	1,782,052	152,708	9 %
AAA	247,114[202]		
CAFÉ Practices	457,339	222,550	49%
Total adjusted for multiple certifications	3,300,000	840,000	25 %

Source: BASIC based on IISD (2014) data[203] generally through community development projects.[176]

Although each company has a different approach, these individual sustainability efforts by midstream and downstream actors are not uncommon. While the extent to which companies embrace sustainability varies considerably, awareness of the need to address sustainability issues, and basic attempts to do so, appear widespread. A 2018 review of ten large roasters and 5 traders, for example, found that all but one (KraftHeinz) offered publicly available information about their sustainability policies and practices.[177]

Within coffee-producing countries, efforts by governments, research institutes, producer associations, innovative companies and entrepreneurs, and producers themselves have focused on achieving greater sustainability within coffee production. These efforts, which are also far too numerous to list here, provide some of the best approaches to achieving sustainability, as they are grounded in local contexts and sustainability needs. One example, from Kenya, is Vava Coffee Ltd., a social enterprise that sources from and works to empower smallholder producers, helping them to earn more through improved quality and increased market access to buyers who pay premium prices.[178] Other examples, from Colombia, are the work of Cenicafé, which undertakes critical research that has led to innovations such as ECOMILL (which allows coffee to be washed using significantly less water and energy),[179] and the National Federation of Coffee Growers of Colombia (FNC), which provides a range of sustainability-oriented services for producers, from support for tree renovation to support in exporting coffee directly (see Section IV(B), below). Excellent examples can be found around the world; one challenge that many national- and local-level efforts face, however, is in surmounting the constraints of business-as-usual global value chains and low-price environments.

Taken together, these collective and individual efforts by a range of stakeholders to integrate sustainability within supply chains and to support broader sustainability within the coffee sector provide hope that the coffee sector will choose the path of sustainable development. These sustainability efforts also demonstrate that roasters, retailers, traders, and other private sector actors are cognizant of the needs and challenges, are willing to take steps to advance sustainability of the coffee they source, and are increasingly working together to address the sustainability challenges that affect the sector more broadly.

However, the collective and individual efforts undertaken to date are also not enough. This is apparent from an impact perspective, when viewed against the current sustainability crisis confronting coffee. It is clear from conversations with various industry actors, who acknowledge much more is needed to scale up sustainability. And it is obvious when viewed in monetary terms, as the amount of money dedicated to sustainability is essentially negligible as a fraction of overall value: less than 0.2% of the annual value of the industry, with about half of that occurring as premiums for certified products.[180]

In addition, these sustainability efforts risk being undermined by business practices and sourcing practices of roasters and retailers that result, ultimately, in even greater pressure on producers. For example, a move away from external certification standards to internal sustainability ones may allow a company to continue purchasing the same coffee from the same producers at a drastically reduced price[181]—clearly suboptimal from a producer perspective. Pressure to reduce the costs of sourcing green coffee similarly can result in efforts to renegotiate prices with long-term producer partners.[182] Even business practices unrelated directly to sourcing, such as the finance terms requested by roasters of traders, may ultimately create additional pressure on producers.[183]

Box 6: Pricing and Transparency

Even when producers are selling high-quality coffee and/or coffee produced under certification standards, various business practices, such as the ones mentioned above, can exert downward force on the prices they receive. Two other factors—a lack of transparency, and a reliance on the C-Price as the starting reference point for many negotiations—can also dampen prices for specialty producers, for whom the C-Price should be less relevant.

For this reason, disclosing reliable and transparent information on the price paid for specialty coffee both at the farmgate and on an FOB basis could support farmers' and cooperatives' bargaining power, giving them an alternative reference point when negotiating on price. One useful initiative in this regard is the Specialty Coffee Transaction Guide,[204] which provides detailed recent transactional data on specialty coffee purchases. This Guide aims to equip producers and buyers with specialty-grade specific reference points for negotiations, empowering them to move away from commodity prices as a starting point. While one potential challenge for the Guide is that specialty buyers who otherwise would pay higher than average prices might use the data to instead justify paying closer to the average, the Guide nevertheless presents a useful tool for helping the specialty coffee community move away from using the C-Price as a price discovery mechanism.

Although the Specialty Coffee Transaction Guide is not relevant for producers of commodity coffee, greater transparency around costs of production and value captured throughout supply chains could similarly help commodity coffee producers to negotiate on price. During the current low-price crisis, many coffee producers have sold coffee at prices that do not allow them to recoup their costs of production. While many coffee brands are generally aware of this, the lack of data on costs of production arguably helps to perpetuate this situation. Disclosure of data on costs of production and value captured could help to articulate new price discovery mechanisms—such as a commitment to pay prices that cover costs of production.[205] Producers or traders can potentially use information on costs of production in their negotiations with potential buyers, to ensure that prices do not go below costs of production.[206]

Other initiatives promoting greater transparency and corresponding consumer awareness could also help stimulate support for higher prices to producers. For example, the World Coffee Producers Forum has proposed an economic sustainability seal,[207] while Le Basic has proposed that coffee product packaging include explanations of how payments were divided among producers, intermediaries, and downstream actors.[208]

This sustainability gap, between what is needed and what has been done to date to advance sustainability, existed before the most recent price crisis. So too has the tension that occasionally exists between sustainability investments and general business practices. Yet the price crisis has illuminated just how far the sector has to go, and how inadequate current efforts are to achieve sustainability in the face of market forces and climate change. Much more is needed, and soon, to build on what has worked, to scale up efforts across the sector, and to facilitate new efforts to fill coffee's sustainability gap. Below, we present recommendations for doing so.

IV. Recommendations – Partnering for Sustainability Investments and the SDGs, and Supporting Increased Economic Viability of Producers

Coffee's sustainability crisis has thrown into stark relief one indisputable fact: the current structure of the coffee industry is not working well for most producers. While market power has consolidated amongst roasters and retailers, who are flourishing closer to the consumer end of the value chain, producers in many countries are struggling. As our model shows, all producers are vulnerable to climate change. Nearly all are price-takers. And because of this, in low price contexts, many cannot cover their costs of production, let alone earn a decent living.

There are multiple points along the coffee value chain where value is created and extracted, through actions by and payments to specific actors. These points offer opportunities to consider how producers can capture more of the final retail price of coffee, as well as to identify mechanisms for increasing the investments necessary to make coffee truly sustainable.

In consideration of these opportunities, as well as of the challenges facing the coffee sector today and in the future, we make two broad recommendations. First, we suggest that each coffee-producing country develop a National Coffee Sustainability Plan, the implementation of which would be financed in part by an ambitious but feasible initiative to achieve a sustainable coffee sector: a Global Coffee Fund (GCF). The GCF, in turn, would facilitate a broader public-private partnership to invest in sustainability throughout coffee production and in coffee regions, including by equipping producers to be more profitable and resilient. Second, we recommend that producing countries as a group seriously examine two options for capturing more of the retail price of coffee: requiring a minimum quality-adjusted price (discussed above in Section II(a)), and supporting producers to harness the potential of new technologies (e-commerce and targeted mobile applications) to change their business models towards greater participation in sales to consumers. Although both of these latter options have been tried and have partly or largely failed in the past, we believe that the current market dynamics, along with new opportunities offered by e-commerce, might make such options possible at this point. We turn first to the national plans and the Global Coffee Fund.

A. National Coffee Sustainability Plans and the Global Coffee Fund

1. National Coffee Sustainability Plans

Given the realities of the global coffee market and the climate crisis, producing countries need national sustainability strategies to support their producers and their coffee lands. In the absence of clear plans and corresponding actions, the global coffee market and climate change will remain brutally unforgiving for producers.

While the general challenges are universal, the context-specific challenges and opportunities confronting producers and producing countries are distinct. In some places and for some producers, coffee may never be more than a poverty crop, unless concerted efforts are undertaken to support producers, improve their enabling environment, and otherwise address existing challenges. Even still, those steps will not be enough for marginal producers with extremely small landholdings, or for producers located in areas where climate change will be unforgiving. In other places and for other producers, coffee production offers a more viable future, yet producers will remain at the mercy of global market forces and climate change, unless concerted efforts are taken to limit and buffer the impacts of those factors.

Photo by Nathan Dumlao on Unsplash

We suggest that each coffee-producing country develop a National Coffee Sustainability Plan (NCSP), that accounts for differentiated needs, challenges, and opportunities within the country. NCSPs could serve as a tool for coffee-producing countries, their producers, and other relevant stakeholders to assess clearly, plan effectively, and act strategically. NCSPs would offer a mechanism for taking stock of: (1) current and likely future prospects for producers (differentiated by size, region, and other relevant factors) regarding coffee production and sales, particularly in light of expected climate change impacts, and (2) SDG track record and sustainability gaps within coffee production and coffee-growing regions.[209] Based on these assessments, an NCSP would provide a platform for envisioning the coffee future that producers and other relevant stakeholders in the country want and can realistically achieve, and for determining the steps needed to get there. Colombia, as one example, has already begun to develop such a plan, based on sub-regional assessments and aligned with the SDGs.[210] At their core, NCSPs would offer clear strategic plans for supporting producers, promoting sustainable coffee production, and aligning producing regions with the SDGs.

While the SDGs provide a relevant framework for coffee-producing regions and the coffee sector generally, each coffee-producing country is starting from a distinct position, with its own needs and opportunities. Local design and ownership of NCSPs means that relevant stakeholders within each country—including producers and their associations, policymakers, private sector actors, civil society and research institutions, and others—should determine the appropriate priority activities and approaches necessary for investing in coffee sustainability within the country. The design of NCSPs should thus be done through multi-stakeholder, participatory, inclusive, and transparent processes.

There will not be a one-size-fits-all approach. Our research suggests, however, that each NCSP should include a focus on some or all of the following collective goods (some of which are interrelated) that could help fill short-term and long-term needs:

- **Developing and implementing comprehensive climate change adaptation strategies**, to help achieve SDG 13 (climate action and resilience). Depending on the likely climate impacts in specific areas, adaptation may need to be incremental, systemic, and/or fully transformative.[211] Under any of those approaches, producers may need financial or technical support for implementation. Climate change adaptation strategies should also include the participatory creation and subsequent dissemination of **affordable insurance options to reduce climate-related risks** for producers (see Box 9). For some countries, it may also include the development of a **disaster relief fund** to help smallholder farmers recover from the shocks of climate-induced extreme events.
- **Ensuring on-farm financing options at attractive rates for producers**, including for women, who could use the financing to invest in productivity-enhancing activities (such as mechanization, irrigation, inputs) and to adopt climate-smart practices. This would help to achieve SDG 1 (ending poverty), SDG 2 (sustainable agricultural practices), SDG 5 (gender equality), SDG 13 (climate action and resilience), and SDG 15 (life on land). In many coffee-producing countries, producers do not have sufficient access to affordable credit or to financial products that are adjusted to the coffee crop. This can affect producers' ability to invest, to weather difficult circumstances, or to make otherwise rational selling decisions. In these countries, concerted efforts may be necessary to bridge this gap, including through subsidization that helps to lower the risk of such products for financial actors. Any significant expansion in credit opportunities, however, should be accompanied by borrower education and other safeguards to reduce the likelihood of producers becoming trapped in cycles of indebtedness.
- **Strengthening on-farm support to viable small- and medium-scale producers with a focus on increasing their profitability**, **whether through increasing efficiency, increasing productivity, and/or increasing quality.** This includes but is not limited to mechanisms such as funding and disseminating **agronomic science and improved cultivars**, expanding **extension**

services as needed, supporting access to **affordable and optimized inputs**, and/or improving **irrigation**. It may also include other types of support, such as ways to **track costs of production** so that producers can better factor them into decision-making.[212] All of these various mechanisms should include support for women, and should also be designed to improve climate resiliency. In some places, they may require a careful balancing act to ensure that efforts to increase productivity are not grounded in environmentally unsustainable practices.[213] In developing the NCSP, stakeholders should also think critically both about what is possible within the current bounds of productivity, as well as what might be possible in terms of increased productivity and efficiency. These approaches would help to achieve SDG 1 (ending poverty), SDG 2 (sustainable agricultural production), SDG 5 (gender equality), SDG 9 (innovation), SDG 13 (climate action and resilience), and SDG 15 (life on land).

- **Implementing other improvements to the enabling environment for farmers.** This has several dimensions: a legal and policy dimension (including commitments to **formalize and protect land rights** of small-scale producers), a physical dimension (e.g., **improving or increasing physical infrastructure** such as roads and storage facilities), and an information dimension (e.g., increased market information). This could also help to achieve SDG 1 (ending poverty), SDG 2 (sustainable agricultural production), SDG 5 (gender equality), SDG 9 (infrastructure) and SDG 15 (life on land).
- **Supporting producers' market opportunities, both internationally and domestically.** On the international front, producers could be supported in their efforts to market more directly to smaller buyers or consumers (see Section IV(B), below); this may include more institutional support in developing a destination marketplace for that country's coffee, as well **as institutional support to producers** in navigating import requirements, in accessing low-cost shipping, and in dealing with the other administrative and logistical challenges that may arise. On the domestic front, policies that **encourage more domestic consumption** of coffee can help to shield producers from disadvantageous exchange rates and can provide an avenue for coffee that is harder to export. This support could help to achieve SDG 1 (ending poverty).
- **Providing income support to the poorest farmers during periods of sustained low prices**, to help achieve SDG 1 (ending poverty), SDG 2 (zero hunger), and SDG 8 (decent work, including no child labor). This would essentially be akin to a second payment for farmers, beyond what they originally received for their coffee, in recognition that the market is currently failing to internalize the full value of coffee and that the poorest farmers need some form of social protection. Income support is discussed further in Box 7.
- **Improving access to basic services, including healthcare, quality education, safe water and sanitation, electricity, and justice,** to achieve SDG 3 (good health and well-being), SDG 4 (quality education), SDG 6 (clean water and sanitation), SDG 7 (clean energy), and SDG 16 (peace, justice, and strong institutions).
- **Strengthening government capacity in rural areas to monitor farmworker conditions and enforce compliance with labor laws**, including payment of the minimum wage and avoidance of child labor, as well as strengthening government, civil society, and community capacity to monitor deforestation and other environmental harms. This could help to achieve SDG 8 (decent work), SDG 13 (climate action), SDG 15 (life on land).

The activities to be undertaken through NCSPs should be designed and implemented using a gender-sensitive approach (SDG 5). Implementation of many of these activities, as well as related monitoring, could also be facilitated in many cases through the use of mobile applications, new technologies, and other innovations (SDG 9).

These collective goods require significant investment. Many of them are the co-responsibility of public and private sector actors, and many of them will not be fully possible without an intensive multi-stakeholder partnership. Below, we describe how a Global Coffee Fund could make this investment, and thus coffee sustainability, a reality.

2. A Global Coffee Fund Underpinned by a Multi-Stakeholder Approach

A Global Coffee Fund (GCF), financed by the main coffee industry actors and used to leverage additional public sector funding, would enable stakeholders to implement activities under the NCSPs. Such a Fund would serve as the backbone to the intensive multi-stakeholder efforts needed to make coffee production sustainable and to support coffee-growing regions to achieve the SDGs.

The GCF would multiply, at a far greater scale, the public-private efforts that have been undertaken by specific companies within their own coffee supply chains, and would ensure the necessary financing for more robust and comprehensive sustainability efforts within coffee production and coffee-growing regions. In short, the GCF would be a key pre-competitive initiative of the coffee sector as a whole, in order to fill critical financing gaps for sustainability investments.

The GCF is not charity. Rather, it is an avenue for downstream and midstream actors such as roasters, retailers, and traders to fulfill their co-responsibility for achieving a sustainable coffee sector and to shoulder more of the risks that currently fall too heavily on producers alone. In doing so, the GCF provides a mechanism to leverage the financing needed for significant investments in sustainability.

These sustainability investments would help to directly support the implementation of activities under the locally owned NCSPs. Funding from the GCF, along with complementary public funds and private-sector company investments in their own supply chains, would aim to fill the largest sustainability funding gaps in the global coffee sector, and to enable provision of the collective goods that can help producers to thrive in an era of increasing market consolidation and climate change.

All low- and middle-income countries that grow and export coffee would be eligible to receive GCF funding and matching funds. To fill the largest sustainability gaps, significant funding would be prioritized for the poorest countries and poorest regions within middle-income countries, as well as for the poorest actors within value chains: smallholders and farmworkers.

The Global Coffee Fund embodies a multi-stakeholder approach at three levels. First, the GCF catalyzes multi-stakeholder financing. As discussed below, the GCF would be a pre-competitive effort, with contributions from the main coffee industry actors, including roasters, retailers, and traders. That pre-competitive industry funding would be complemented by: 1) increased funding by bilateral and multilateral donors, 2) increased commitments in the national budgets of coffee-growing nations, and 3) commercial investments by the private sector within their own value chains. Second, the GCF would be governed at the global level by a multi-stakeholder Governing Board, potentially including, for example, representatives of the major global companies, national grower confederations, smallholder farmer representatives, and participating donor governments. Third, the GCF would co-fund the implementation of the National Coffee Sustainability Plans described above, which would be designed and submitted by multi-stakeholder Country Coffee Platforms (CCPs). Together, these various multi-stakeholder collaborations would provide a public-private partnership to achieve the SDGs and other sustainability goals, at scale, within the coffee sector.

3. Operations and Governance of the GCF

The operations and governance of the Global Coffee Fund would integrate multi-stakeholder oversight, local ownership of planning, and independent expert support. Governance mechanisms would be designed to guard against corruption and fraud. To minimize redundancy and the need to develop entirely new bureaucracies, the GCF could potentially be hosted by one or more existing multi-stakeholder initiatives focused on coffee sustainability.[214]

Box 7: Income Support and Social Protection

Historically, efforts to support farmers confronting low prices have centered on input and output subsidies. By lowering the price of inputs, raising the price of outputs, and/or by serving as a guaranteed buyer, governments can increase the marginal returns of agricultural production. However, both subsidies/premiums and price floors tend to help larger farmers more than smaller farmers, given that benefits are proportionate to sales.[269] In addition, price support systems have caused market distortions, reduced domestic consumption, and either encouraged oversupply—with a consequent lowering of the world price of the subsidized product—or required complicated supply management efforts.[270]

Past coffee price support efforts at different levels have also failed to reach their objectives over the long-term. For example, at the multilateral level, producing and consuming nations signed the first International Coffee Agreement (ICA) in 1962 with the aim to stabilize the price of coffee above the price created by the free market through a quota system. The quota system ended in 1989, however, following political disagreements at all levels of the system (between consuming and producing nations, within producing nations, and within the supply chain in producing nations).[271]

At the country level, multiple governments have established price stabilization funds as a mechanism to provide support for coffee farmers. While some of these funds pre-dated the ICA's quota agreement system, others have been set up following its collapse. Stabilization funds are used to provide price support to dampen the effect of low prevailing coffee prices. In times of crisis, other countries have instead established a loan platform with favorable terms for farmers. Stabilization funds and loan platforms are established either through direct Government funding or through the issue of coffee bonds. Both types of mechanisms have relied on farmers to replenish the funds when prices are high through a levy per unit of production. But stabilization funds and loan platforms have often been designed in a way that do not replenish the funds. This has resulted in the funds having to borrow from the Government or issue additional bonds, which has increased the debt of farmers. Both mechanisms have also been criticized for doing little for the poorest farmers who can afford neither a tax nor a credit.[272]

While price support systems in coffee have run into significant challenges, there may be potential for renewed efforts to develop a minimum price for coffee, as noted in Section II(a), above, that would not require supply management. However, such a minimum price would need to remain relatively low.

More generally, income support systems in the agriculture sector have fared better. They are now the preferred mechanism adopted by jurisdictions such as the European Union, the United States, and India.

Because income support avoids some of the challenges tied to price support, we suggest that the Global Coffee Fund, as well as the matching public funds, could be used in part to provide income transfers to the poorest coffee farmers, particularly during sustained periods of low global prices. These transfers would essentially serve the function of a supplemental payment for the coffee that farmers have sold, in recognition that the market is failing to internalize the full value of coffee. Various mechanisms could be considered for implementing this. Non-profit entities that have developed methodologies for identifying farmers (such as Enveritas) and for implementing cash transfer programs (such as Give Directly) could be mobilized to help develop national rosters of coffee farms and to support income transfers to those operating the farms. Alternatively, coffee income support payments could potentially be integrated into existing social benefits programs[273] with the support of international donor agencies.[274] The banking[275] and mobile phone sectors[276] could play an important role in facilitating the transfers.

One of the most critical aspects of designing country-specific income support programs for coffee farmers, to be funded in all or in part by the GCF and matching public funds, would be in setting parameters for the recipients. In setting these parameters, stakeholders would want to take into account the cost of targeting, in order to develop a cost effective approach that facilitates support to the poorest farmers.

In Table 6, below, we provide an estimate of the income support that would have been needed to raise most smallholder coffee farmers above the poverty line of 1.90 international dollar/day under 2017 prices and costs.[277]

The GCF would be governed by a **multi-stakeholder Governing Board**. The Board could be comprised of representatives of major global coffee companies contributing to the Fund, national grower confederations, smallholder farmer representatives, farmworker unions, and other relevant stakeholders. Donors and producing country governments that contribute significant matching funds could potentially serve as non-voting members. Participation on the board could occur through a rotating system, to enable geographic diversity and to ensure that each stakeholder has sufficient representation, while maintaining a manageable size.

The GCF's Governing Board would have multiple functions, some of which would change as the Fund moves from concept to implementation. At the beginning, the Governing Board could help support the initial design and function of the Fund. This could include, for example, determining the length of the funding cycle—which could respond to business cycles, coffee planting cycles, and/or matching donor cycles[215]—and deciding how funding might be prioritized and allocated across countries. After the Fund were established, the Board's roles could include making final funding decisions, and providing oversight of the Fund and its management.

The GCF would co-finance—along with public funding and, potentially, private sector competitive investments—the implementation of the National Coffee Sustainability Plans, discussed above. These NCSPs should be designed in a transparent and participatory way that allows input from a range of relevant stakeholders. We suggest that they could be prepared and submitted by **Country Coffee Platforms (CCPs)** in each coffee-producing country.

The CCPs would include representatives of groups relevant to the coffee sector and coffee regions within the country, such as producer associations, farmer cooperatives, governmental line ministries, private sector actors, civil society organizations, and research institutions. Where possible and desirable, the CCPs could build on existing National Coffee Platforms that have been facilitated by the Global Coffee Platform (GCP). Alternatively, or in producing countries without pre-existing platforms, stakeholders might integrate lessons learned from the GCP's country platforms into the design of the CCP. In short, where possible, the CCPs could build on successful existing initiatives that have in-country support, rather than setting up a separate entity.

On the basis of the NCSP, the CCPs would develop and submit a funding request to the GCF, setting out how the country's implementation partners would use the allocated funds if approved by the GCF. The request would also identify other proposed funding sources and implementation partners to support specific activities under the NCSP. Aside from the GCF, this would include national budgets, external donors, and private sector investments in their respective supply chains.

Upon receipt of a proposal for funding, the NCSP could be reviewed by an **Independent Review Panel (IRP)**. The IRP should be composed of individuals with expertise on the SDGs, the coffee sector, and relevant country contexts, and drawn from a range of relevant disciplines such as agronomists, economists, engineers, and climate scientists. The IRP would make recommendations (fund, deny, or revise and resubmit), while the GCF multi-stakeholder Governing Board would take all final funding decisions.

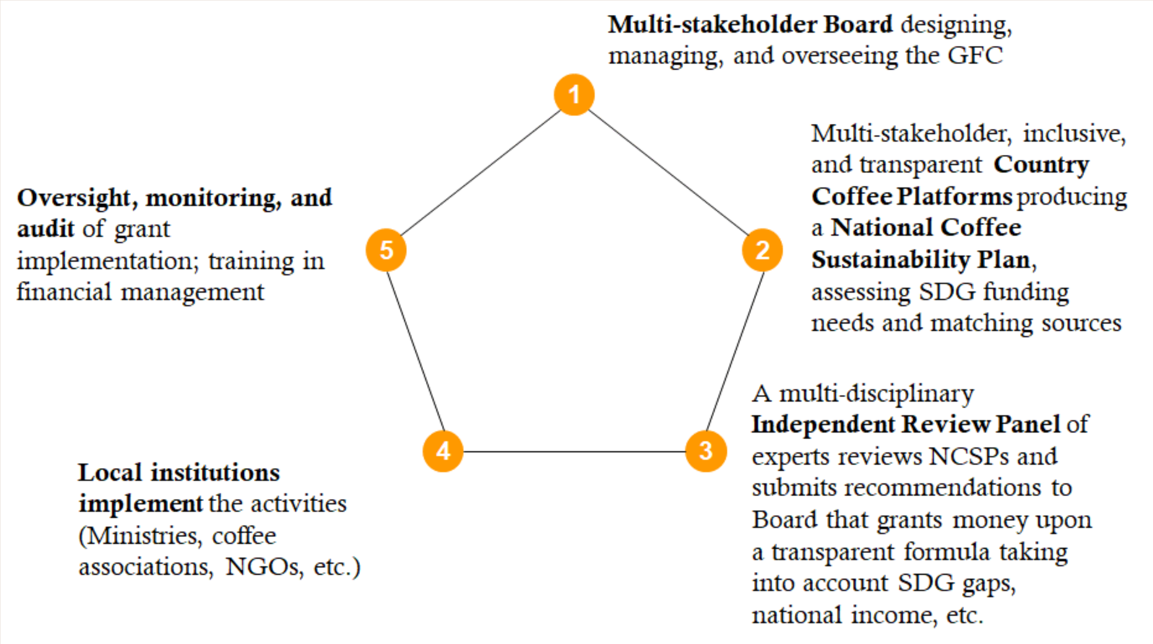
The IRP's recommendations would take into consideration the **transparent formula or set of parameters developed by the GCF Governing Board, in partnership with the IRP, for decision-making around funding allocations** to individual countries. Such formula might include a range of factors, such as national or regional income, the SDG gap for the priority activities mentioned above, the state of the enabling environment for coffee production and the potential to improve it, and the quality of the national institutional process put in place to implement funding received from the GCF. The formula might also include an assessment of the potential for various proposed activities to be funded by matching public contributions or private sector competitive investments. At the outset, the IRP and GCF Governing Board might also use a partial "first come, first served" approach, whereby some priority is given to proposals based on when they are received, while still ensuring that decisions are taken under the guidance of these other factors.

An **independent evaluation unit** for the GCF could monitor and evaluate programs throughout grant implementation using progress updates and country visits. The results of evaluations would be made publicly available. Moreover, financial activities would be monitored and verified through audits, which would also be disclosed publicly. This evaluation unit would also be in charge of providing necessary training in financial management to the relevant CCPs or implementing agencies, as needed. Experiences in this regard can be learned from the Global Fund to Fight AIDS, Tuberculosis and Malaria, which has deployed a set of tools to enable country programs to "control and mitigate operational fiduciary and financial risks related to grant implementation,"[216] including through disseminating guidelines, a handbook, and a list of pre-qualified service providers that can support country platforms with technical assistance in financial management.[217]

Many of these operational and governance suggestions are modeled on those used for the Global Fund to Fight AIDS, Tuberculosis and Malaria. The sustainability challenges facing the coffee sector are, of course, very different from the global health context that predicated the creation of the Global Fund to Fight AIDS, Tuberculosis and Malaria. Clearly, that Fund should not be viewed as an exact blueprint for any effort undertaken in the coffee sector. At the same time, however, the Global Fund to Fight AIDS, Tuberculosis and Malaria proved that large amounts of multi-stakeholder funding can be channeled to address complex challenges relevant to both the private and public sectors. It also has demonstrated the value of developing national plans through multi-stakeholder mechanisms, using an independent panel of experts to review national proposals, and having approvals go through a governing board. In light of its successes, we suggest that it is appropriate to take inspiration, if not an exact blueprint, from such a Fund.

At the end of each funding cycle, the GCF could be responsible for producing an SDG report of the coffee sector on the basis of all the NCSPs and progress realized under their implementation. This report could include reporting on SDG indicators, targets, and key coffee metrics (including, for example, the breakdown of costs of production, the number of farmers and workers working on coffee within the country and

Figure 42: Overview of the Global Coffee Fund Organizational Structure[278]



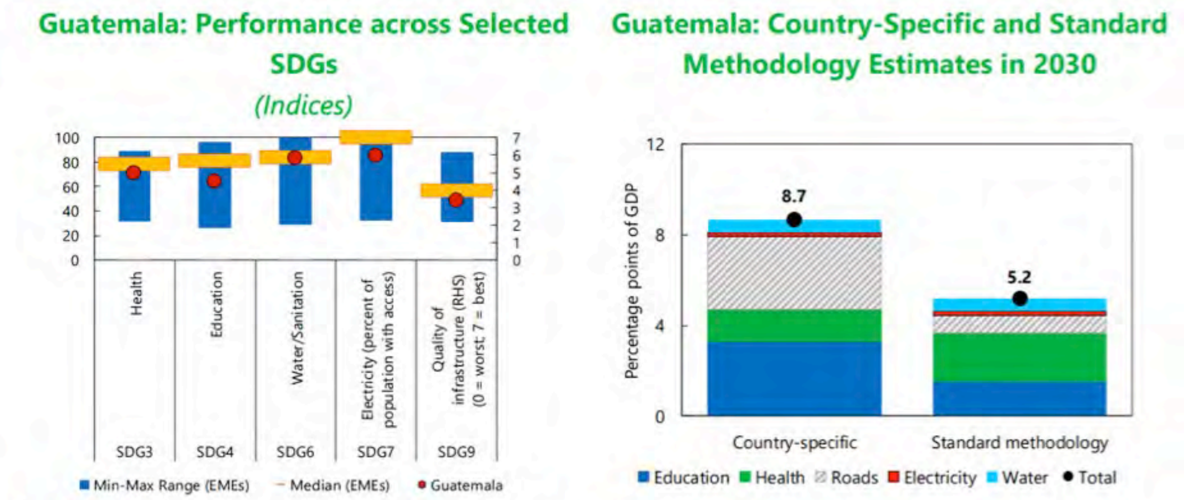
benefiting from programming supported by the GCF and by matching funds, etc.). The report could also document relevant stakeholders' funding efforts and contributions. Such an undertaking would fill an important gap, as sustainability in the coffee sector cannot happen without good data, traceability, and transparency.

4. Scale of Effort and Financing of the GCF

As outlined above, the GCF would support coffee-producing regions in achieving the Sustainable Development Goals and to make a significant difference in integrating sustainability within the coffee sector and in coffee-growing regions. While a more detailed analysis of the costs required to help achieve the SDGs in coffee-producing regions and along the coffee value chain would be needed, the below estimates from existing studies can help give a sense of the scale.

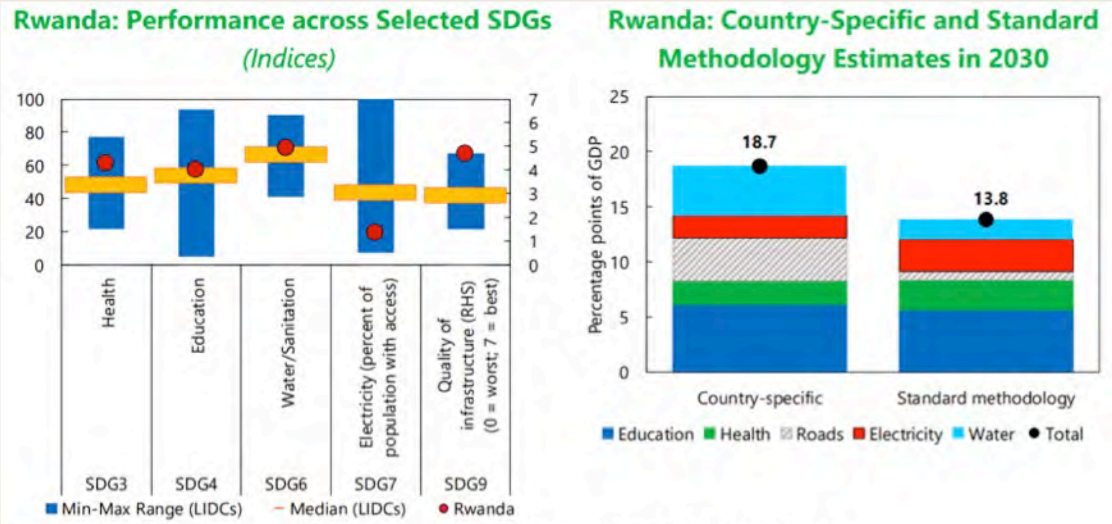
Several efforts of late have sought to estimate how much it would cost to achieve the SDGs. For example, the International Monetary Fund (IMF) has recently estimated the costs associated with the achievement of SDGs 3 (health), 4 (education), 6 (water/sanitation), 7 (electricity) and 9 (quality of infrastructure) at the global scale and in five country case studies.[218] Among the five country assessments are Guatemala and Rwanda, which are coffee producers. For Guatemala, the IMF estimates an annual cost of US$6.8bn and for Rwanda US$1.8bn. The figures below show how these two countries perform across the five SDGs and how the costs are divided by sectors.

Figure 43: SDG Performance and Funding Requirement for Guatemala



Sources: IMF staff calculations, SDG Index and Dashboards Report 2018, World Economic Forum.
Note: EMEs = emerging market economies; RHS = right scale.

Figure 44: SDG Performance and Funding Requirement for Rwanda



Sources: IMF staff calculations, SDG Index and Dashboards Report 2018, World Economic Forum.
Note: LIDCs = low-income developing countries; RHS = right scale.

The above figures do not isolate the coffee-producing regions. To do so, we can use the latest per-capita cost and financing gap estimates from the SDSN SDG Financing Team, which is working with the IMF, World Bank, OECD and other multilateral institutions to develop more refined cost estimates for the achieving the SDGs in low and lower-middle income countries.[219] The methodology builds on the Move Humanity (2018)[220] report, and includes cost estimates for health, education, infrastructure, biodiversity conservation, agriculture, social protection, access to justice, humanitarian aid and SDG data collection and monitoring efforts. After estimating the per capita costs for low and lower-middle countries, the existing outlays by governments and donors are subtracted to get to the financing gap estimate. Using the smallholder farmer estimates by Enveritas[221] for the low-income countries (Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda) and lower-middle income countries (Honduras, Laos, Nicaragua, Papua New Guinea and Vietnam) and assuming that each coffee producer has four dependents, we come to an annual financing gap estimate of $9bn for these countries.

Another useful calculation to provide an indication of the required scale of the GCF is provided in Table 6. It estimates across major coffee-producing countries the social protection payments that would have been needed in 2017 to help smallholder coffee producers receive an income above the extreme poverty line of 1.90 international dollars per day. In a low-price environment like the one observed in recent years, the GCF could play an important role in keeping smallholder coffee farmers above the extreme poverty line, while also supporting them to understand their long-term viability and future prospects. Decisions to be made for each country include what eligibility parameters to use, as well as the amount of supplemental income that might be offered. This amount would presumably differ across countries, and should be set at the infra-marginal level: it should be, on the one hand, low enough to avoid encouraging non-viable farmers from remaining in coffee production long-term or additional farmers from joining the coffee sector, while, on the other hand, high enough to ensure that, in the short term, farmers avoid extreme poverty. The assessment of this amount would also take into account whether a minimum price (as discussed in Section II(a)) is implemented.

Table 6: Estimation of the Transfer Needed in 2017 to Raise Smallholders Above the Poverty Line (in Millions)[279 280]

Country	Smallscale as % of total production*	Net income (2017$/Ha)**	Gap per Ha to make above poverty threshhold of $1.90	Transfer to Smallholders (National definition - US$ million)
Brazil	70%	$ 710.00	$ (16.50)	
Tanzania	95%	$ 680.00	$ 13.50	$ 4.55
Ethiopia	86%	$ 500.00	$ 193.50	$ 425.70
Honduras	95%	$ 480.00	$ 213.50	$ 25.71
Kenya	65%	$ 480.00	$ 213.50	$ 109.74
Colombia	70%	$ 440.00	$ 253.50	$ 140.57
Nicaragua	50%	$ 420.00	$ 273.50	$ 11.82
Peru	75%	$ 120.00	$ 573.50	$ 115.90
Vietnam	97%	$ 1,180.00	$ (486.50)	$ -
Indonesia	99%	$ 730.00	$ (36.50)	$ -
Uganda	99%	$ 540.00	$ 153.50	$ 276.30
TOTAL subgroup (85% of world coffee supply in 2017)				$ 1,110.28
TOTAL				**$ 1,723.54**
*Enveritas				
** GCP - Economic viability of coffee farming				

The estimates suggest that the amount of money needed to make considerable progress on achieving the SDGs in coffee-growing regions, through the activities discussed above, is in the region of US$10bn per year. As discussed further below, the precompetitive contribution by industry would not be expected to cover purely public goods and services that are primarily the remit of government (e.g., health and education), which could instead be covered by the leveraged public funds. We provisionally suggest a goal of raising $2.5bn per year through pre-competitive private sector contributions to the GCF. Using the 2018 global export number of 7.3bn kg of green coffee,[222] this would amount to 34 cents per pound of green coffee contributed to the GCF, which is in the range of 0.25 - 0.50 cents per cup.[223] **In other words, the targeted level of funding would require no more than half a penny per cup sold.**

These dedicated pre-competitive contributions by coffee industry actors should be a strong signal to the public sector to also do more. We thus suggest that this amount of $2.5 billion be matched by bilateral and multilateral donors for work in coffee-growing regions, and that it also be matched by national budget outlays of producing-country governments on programs that support SDG achievement in coffee-growing regions. This matching annual funding would create an additional $5 billion to put towards things like improved access to basic services in coffee-growing regions, and strengthened efforts to support farmers and workers.

We also expect that additional competitive investments by the private sector that support sustainability within specific value chains could also rise to roughly equal levels. These investments would largely be expenditures by roasters, retailers, and traders that support the farmers within their value chains. Competitive investments could also include changes in business practices that would result in companies sharing more of the risks typically shouldered by farmers (through, e.g., long-term fixed price contracts, a willingness to purchase lower-quality coffee when quality was affected by climate variables, etc.).

Taken together, this would result in a 25% allocation of the overall funding goal for each main source of funds: the GCF, donors, producing-country governments, and competitive private sector investments. Such an approach would embody a public-private partnership grounded in equally shared responsibility between the public and the private sectors.

While these private sector and public sector funds would be roughly equal at the global level, money from the GCF would not have to be distributed in equal proportions for each participating country. Indeed, it would be appropriate for the GCF to allocate different amounts of money to each country, as well as to fund different percentages of the full amount required for implementation of National Coffee Sustainability Plans (which will also be funded by public funds and, potentially, private sector competitive investments). Doing so would enable the GCF to support all coffee-producing countries, while also taking into consideration the country-specific needs and funding opportunities that each country has (e.g., government budgets, private sector competitive investments), as well as prioritizing the SDG gaps in the poorest places and for the poorest producers and workers. For example, the GCF might decide to contribute 10% of an NCSP's implementing costs in a country with large national budgets for basic services and significant private sector sustainability investments in coffee supply chains, and where a strong enabling environment for farmers already exists. Yet the GCF might determine that covering 30%, or even 50%, of an NCSP would be prudent in a country with significantly higher SDG gaps and significantly fewer opportunities to leverage additional support from government budget lines and private sector competitive investments.

In addition, these different funding sources would not necessarily be allocated to the same types of activities under an NCSP. The GCF would finance pre-competitive efforts focused in particular on supporting sustainable coffee production and ensuring farmer sustainability. This would include prioritizing support for activities that advanced social protection for the poorest farmers, widespread climate resilience, and public goods that result in improved productivity and profitability for farmers, such as opportunities outside of supply chains to access credit, inputs, and agronomic support. By contrast, the competitive private sector contributions would be commercially oriented, applicable to each company's own value chain, and aiming at goals such as improving the productivity, efficiency, and climate resiliency of farmers within their specific value chains. Public matching funds would include domestic budget outlays supported by bilateral and multilateral donors, and would target national development prerogatives, such as improved access to healthcare, quality education, clean water and sanitation, electrification, justice, and social protection.

The relative financing priorities among these actors might thus look as outlined in the adjacent Table 7.

Investments in some of these activities could potentially be implemented using a "blended finance" approach. Similar to the Global Fund to Fight AIDS, Tuberculosis and Malaria, the GCF could allocate a small portion of the Fund—potentially matched by donor funds—to be used as "blended finance" for catalytic investments. Traditionally, blended finance is a way to use initial donor funding to mobilize private sector finance, by helping to mitigate investment risks or otherwise make more viable investments that hold development potential.[224] The dedicated catalytic funding portion of the GCF, along with matching donor funds, could play this role, for example, by providing a risk-sharing mechanism, such as a first-loss guarantee. An example of this approach is discussed in Box 4, above, which describes the goals and model of the Farmfit Fund. Additional relevant examples of blended finance initiatives that aim to support smallholder farmers in coffee regions are highlighted in Box 8, below. Catalytic funding could be used for several of the main activities that the GCF might prioritize. Classic examples would include catalytic funding to increase farmers' access to credit and to increase farmers' access to affordable insurance options that mitigate climate risks (see Box 9).

Table 7: Relative Financing Priorities in the Coffee Supply Chain

SDG Category	Global Coffee Fund	Private Sector	Domestic Budget Outlays	Donor Agencies (bi- and multi-)
Social Protection	✓	✓	✓	✓
Sustainable Farming (including on-farm support and improvements to the enabling environment)	✓	✓		
Healthcare			✓	✓
Education			✓	✓
Gender	✓	✓	✓	✓
Water and Sanitation			✓	✓
Electrification			✓	✓
Decent Work and No Child Labor	✓	✓	✓	✓
Coffee Innovation	✓	✓		
Supporting Market Opportunities and Innovative Business Models	✓	✓	✓	✓
Responsible Consumption and Production		✓		
Climate Resilience and Adaptation	✓	✓	✓	✓
Sustainable Land Use	✓	✓	✓	✓
Access to Justice			✓	✓

Box 8: Blended Finance Projects in Coffee-Growing Regions of Nicaragua and Ethiopia

In Nicaragua, a partnership between the International Finance Corporation (IFC), the Global Agriculture and Food Security Program (GAFSP), Atlantic (a subsidiary of the coffee trader, Ecom), Starbucks, and the Inter-American Development Bank (IDB), focuses on providing long-term loans to help 500 farmers replant and renovate their farms following the devastating effects of the coffee leaf rust disease. GAFSP will provide a 25% first-loss guarantee for a $30 million loan program in which Atlantic and Starbucks invest $3 million each.[225]

In Ethiopia, a partnership between the IFC, GAFSP, Nib Bank (an Ethiopian Bank), and TechnoServe provides a risk-sharing facility of $15.2 million to expand financing to cooperatives. The financing will enable the cooperatives to source coffee cherries from farmers for wet milling, thereby adding value.[226]

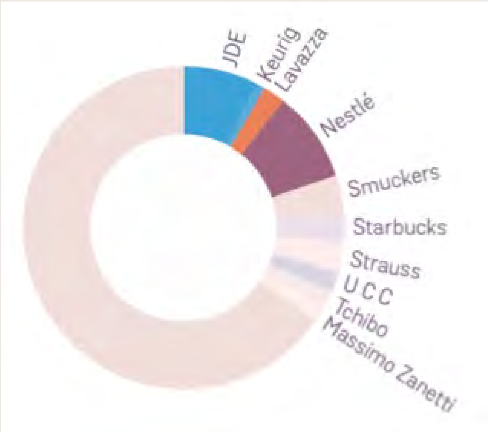
The scale of contributions suggested for the GCF is much higher than the current sustainability spend within the coffee industry, yet it is entirely reasonable as a fraction of the overall value of the industry, particularly given the significant benefits that would accrue to coffee industry actors if a sustainable coffee future were realized. As the GCF would provide significant benefits for the coffee industry overall, and for the largest operators within it, we suggest that the largest roasters, retailers, and traders should be both the forerunners in contributing to the fund, as well as the entities that contribute the most. These actors have outsized impacts on the industry, should have particularly strong interests in a sustainable coffee future, and proportionally have the largest responsibilities for ensuring the long-term sustainability of coffee value chains. Figure 45, below, shows the largest roasters and traders in the industry as of 2018.

The Governing Board of the GCF could be tasked with creating rules for calculating suggested contributions for private sector coffee actors, and monitoring those contributions. This might include, for example, developing **suggested contribution amounts in proportion to market share or based on volumes handled or purchased.** In general, all roasters, retailers, or traders purchasing over a certain threshold amount of coffee per year should be expected to contribute. Roasters, retailers, and traders purchasing less than that threshold could also be encouraged to contribute.

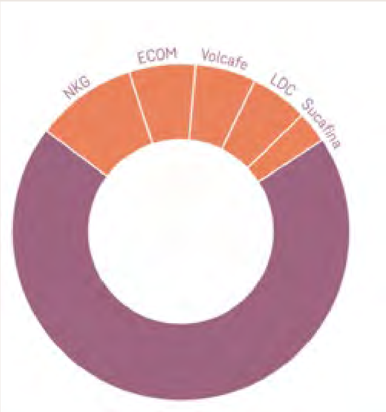
While there are various ways to collect contributions to the GCF, one interesting option in some countries could

Figure 45: Main Coffee Roasters and Coffee Traders by Market Share in Volume

Roasters



Traders



Source: Coffee Barometer 2018[281]

Box 9: Micro Index Insurance

Micro index insurance is designed to compensate smallholder farmers when extreme weather events, such as droughts, floods, and/or excess of rains, disrupt their ability to produce crops and to make future investments that will increase coffee farm productivity.[282] It is potentially more cost effective than traditional forms of indemnity-based insurance, because insured farmers' entitlements to payouts are based on annual weather data, rather than on the physical assessment and verification of losses they actually suffer (which is how indemnity-based insurance payouts are assessed).[283] The cost effectiveness of micro index insurance increases the chances that it can reach more smallholder farmers in the global south.[284] In some cases, index insurance initiatives have sought to target cooperatives of farmers, rather than individual farmers, in order to enhance uptake.[285]

Micro index insurance helps smallholder farmers build their financial resilience. Among other things, it offers the benefit of helping farmers, who pay insurance premiums, to feel financially secure, which can encourage them to take productive risks.[286] This is important, because farmers often lose more from missed opportunities in good years than from the direct failure of crops in bad ones.[287] Micro index insurance can therefore help reduce the precariousness that many smallholder producers, who rely on agricultural production for their livelihoods, experience as climate change makes weather more unpredictable.[288]

One key challenge for micro index insurance is to design indices that reflect the reality of farmers' experiences, so that farmers actually receive payouts when they need them.[289] The design of these indices is also important for insurance providers, who use those indices to set the prices of their index insurance.[290] Designing indices for index insurance typically involves a lot of field-based data collection and analysis about farmers' experiences, which is combined with historical and satellite weather data in order to hone the indices. This data collection can be prohibitively expensive for initiatives seeking to offer inexpensive micro index insurance.[291] Accessing rainfall data that accurately reflect the extreme weather that each farmer faces can also be very challenging, but is essential, as payouts are only made for years that have the most extreme rain fall (whether they are extremely wet or dry).[292]

Most smallholder coffee farmers do not have access to affordable insurance that helps to mitigate climate risks, or to disaster-relief funds that help alleviate the pain of certain weather- or climate-induced events. National Coffee Sustainability Plans could include multi-stakeholder and participatory efforts to co-design and develop either attractive insurance options for smallholders or disaster relief funds for coffee farmers. A Global Coffee Fund could support such efforts in various ways, such as by funding the participatory processes and cost-effective technologies for the design, or by providing catalytic funding necessary to bring in private sector insurance providers willing to offer options at affordable rates.

be the use of a check-off program, a mechanism that World Coffee Research (WCR) has piloted in the coffee sector, and which has also been used for various agricultural commodities in the United States.[227] Through a check-off mechanism, traders could add GCF suggested contributions to the invoices that they provide to roasters and retailers, who would then pay their contributions to the Fund at the same time they paid their invoices. The traders could then transfer those contributions to the Fund itself, for example, on a quarterly basis. Although there are transaction costs to using this type of mechanism, one significant benefit would be that it provides a way to capture payments through existing supply chain transactions, simplifying the collection of contributions.

If a check-off program were used, one important modification from WCR's program to date could be to ask all major traders to offer this service—the option to participate and contribute through a check-off program—

Box 10: Antitrust Safeguards

One common concern that industry actors have when discussing any potential collective effort is whether the effort will raise antitrust concerns. As the Fund is currently proposed, this risk seems exceedingly unlikely. To further reduce antitrust risks, various antitrust safeguards could be implemented into the operation of the Global Coffee Fund. These include but are not limited to:

To the extent the Fund:

- Disseminates data (e.g. out of transparency or reporting considerations) about contributions and data underlying the goals of the Fund:
  - Consider whether the data reveals otherwise confidential sensitive information relating to individual companies.
  - Consider the age of that data, the potential audience, and whether it is sufficiently aggregated. The older the data, the better.
  - For example, publishing data that is 1 year old is better than publishing data about the most recent month every month, particularly if it is traceable to individual companies and the information published allows the calculation of the exact amount of coffee purchased or the price paid
- Communicates with contributors about the amounts they contribute:
  - Do not seek to influence whether or how they pass their contributions on down the supply chain or to consumers in terms of pricing.
  - Do not recommend boycotts of certain suppliers, roasters, or traders if they opt not to participate in a check-off scheme or the Fund.
  - Consider suggesting companies patronize suppliers, roasters, or traders that participate in the check-off scheme or Fund.
- Calculates the recommended amounts contributors could contribute:
  - Do not suggest that contributions are compulsory or fixed.
  - Use an objective, transparent calculation method.
  - Avoid favoritism of specific contributors.
  - Consider taking the amount the Fund would like to raise as a starting point/fundraising target for the calculation.
- Involves leadership from industry actors: consider having a balanced, representative group.

When the Fund holds meetings involving competitors:

- Consider having antitrust counsel present as a safeguard against exchanging competitively sensitive information.
- Draft an agenda and circulate it to the attendees prior to the meeting.
- Ensure that those present are aware that they should stick to the agenda and should not discuss competitively sensitive information.
- Do not allow the meetings to be used for business other than Fund business.

on all coffee invoices. This would help facilitate the broad participation required for the Fund; offering this service would thus be an additional avenue, beyond direct contributions, through which traders could help fulfill their own co-responsibility for supporting coffee sustainability.[228]

Although not yet at a sufficient cumulative level, most major roasters, retailers, and traders are already supporting sustainability initiatives that can contribute to achievement of the SDGs in the coffee sector. Some particular types of sustainability contributions, if declared, transparently monitored, and verified, could potentially be counted against the amounts that specific companies might otherwise contribute to the GCF. One type of sustainability contribution that could trigger such an offset, for example, could be pre-competitive contributions to public goods that would benefit a broad range of coffee farmers, such as the aforementioned contributions to World Coffee Research, which supports climate research to find new varietals. Yet another type of contribution triggering an offset could be undertakings that provide direct income support to farmers during periods of low prices, such as Starbucks's $20 million commitment in 2018 to support Central American producers affected by the low-price crisis through an additional payment meant to enable farmers to more than cover their costs of production.[229]

Taken together, the National Coffee Sustainability Plans and the Global Coffee Fund provide a means to implement the strategic locally-owned actions within countries and the significant investments throughout the sector that are necessary for a sustainable coffee industry and thriving coffee producers. While such interventions have not been tried at scale within coffee-producing countries and in the coffee sector generally, they are indeed feasible, as demonstrated, for example, by smaller public-private interventions that have improved aspects of sustainability on the ground, as well as by the success of the Global Fund to Fight AIDS, Tuberculosis and Malaria, which provides inspiration, although not a blueprint, for a mechanism to channel significant multi-stakeholder funding towards effective solutions to complex challenges.

B. Increasing Producer Profits

The coffee industry has changed significantly in recent years, which has created new challenges for many producers, but also opens up new opportunities for them as well. In particular, two recent transformations within and outside the industry—the high consolidation of the industry and the mainstreaming of e-commerce technologies and mobile applications for farmers—provide unique conditions to depart from the traditional coffee business model that has become increasingly unsustainable for many coffee producers.

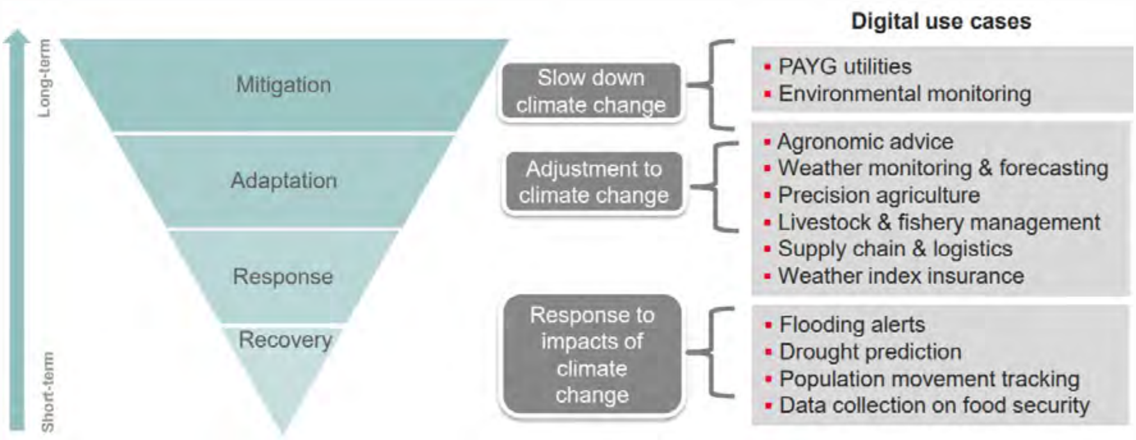
We thus suggest that, along with the National Coffee Sustainability Plans and the Global Coffee Fund, producing countries as a group seriously examine two options for capturing more of the retail price of coffee. The first is implementing a minimum price, which would be linked to a Brazilian reference price and, if not set too high, could be possible without supply management, given the increased buying power of major coffee roasters and retailers. This possibility is discussed above in Section II(a). The second is supporting producers to harness the potential of new technologies to improve their incomes, in particular through more direct sales to consumers. We discuss this latter point next.

Increasing Market Access and Transforming Business Models

Mobile technologies and the Internet have created new opportunities for producers to change the way they do business, improving their business acumen, productivity, resiliency, and access to market; these are presented in this section.

Mobile phones and targeted mobile and web-based applications can help coffee smallholders in certain contexts with a range of issues, sometimes compensating for the lack of agricultural extension officers. Depending on farmers' situations, for example, such applications can help with: 1) locating micro-entrepreneurs who sell inputs at lower prices, thus breaking monopolies of middlemen; 2)

Box 11: Mobile Phone Applications to Support Climate Resiliency



Source: GSMA[293]

One mobile phone application supporting climate resiliency is the GeoFarmer app deployed and piloted in Colombia, Ghana, Tanzania and Uganda by the International Center for Tropical Agriculture (CIAT) in collaboration with the University of Salzburg.[294]

The GeoFarmer app enables farmers to easily collect and share "geospatial data on weather, farm conditions including soil and crop types, and monitor the adoption of techniques to make farms more productive and resilient to climate change."[295] This mobile application builds on research findings that farmers are more inclined to make decisions based on inputs from their peers.

Similar efforts have been undertaken in India, where farmers have used a mobile application that aims to enable climate-smart agriculture. The application provides farmers with tailored advisories on topics such as whether they should harvest early, delay irrigation, or switch to crops that are resistant to flooding, as well as providing insights on crop diseases by allowing farmers to upload photos of affected crops to receive quick advice from agronomists.[296]

calculating farmers' costs of production for better decision-making;[230] 3) providing price information and transparency, thereby supporting farmer decision-making around sales; 4) facilitating access to climate and weather data, thus supporting farmer resiliency (see Boxes 4 and 11); and 5) supporting crop diversification with applications telling farmers which supplemental crops are more profitable and more suitable to, for instance, a drought-prone area. While the expansion of smart phones and accompanying services should generate significant benefits both for farmers and for roasters (through the improvement of the farmers' productivity and resiliency), these benefits are not always realized due to farmer education, age, or access to the Internet. In some contexts, harnessing the potential of mobile technologies thus requires institutional support from a range of stakeholders including the government, producer associations, donors, and/or the private sector.

Moreover, the development of e-commerce has opened up new opportunities to find markets and sell producers' products directly to consumers. This has the potential to reduce market concentration and provide a means for producers to add and capture more value, although the challenges should not be underestimated. These opportunities are most likely to be exploited by relatively larger and better-off coffee producers who produce high-quality coffee, and by coffee producers who can access transparent intermediaries or other entities willing to enter into more equitable partnerships with producers. However, the penetration of mobile phones and the resurgence of cooperatives[231] may help reach smallholders that previously could not have access to these opportunities. Even still, for such opportunities to scale to the benefit of a larger set of smallholders, institutional support through producer associations or similar organizations will prove critical.

Between the producer and the consumer, there are many entities that handle coffee, adding and capturing value along the way. The producer generally receives only a small fraction of the final retail price of coffee.[232] This raises the question of whether it is possible to "cut out" some of the middlemen. Yet the major entities along the value chain all provide important functions or otherwise add certain value that takes green coffee beans in a producing country and turns them into roasted coffee beans or a coffee beverage in a consuming country.[233] A more appropriate question, then, may be whether producers themselves can take on more of these steps and accompanying efforts (such as marketing) to create and capture more value, or whether they can align themselves with entities—either for-profit or non-profit—that provide some of these steps oriented more as a service to producers.

Although value addition in theory can be a way for producers to capture more of the final retail price, it only works if producers understand the consuming market and are able to provide additional value that meets market demands. For example, bad on-farm processing of wet cherries can lead to high rejection rates from buyers; in that case, farmers may be better off selling wet cherries directly to a mill, because they can sell a higher proportion of their crop and ultimately earn more money.[234] Similarly, while roasting adds value to a green coffee bean, poor roasting destroys most of the bean's value. And even when producers or their partners are able to roast beans well, if they are unable to find a market for those roasted beans and can only access markets for green coffee beans, then roasting will not benefit them.[235]

Direct to Consumers

The Internet provides an avenue for online marketing and a platform for commercial transactions that some producers may be able to exploit. Online marketing is a significant way for small coffee companies and certain producers to promote their brand, whether based on social responsibility, coffee quality, or price. Although online marketing offers the potential to reach many more consumers than would previously have been possible for producers or small companies, online retail is also fiercely competitive, and producers can be at a disadvantage given the high consumer loyalty to major brands. To break through the competition, significant offline investments would have to be made by producers and supporting institutions on marketing, quality control, and logistics.

One advantage that producers have is their narrative: the story of who they are, and why consumers should buy their coffee. Yet this narrative is only compelling to a segment of the market, and the marketplace is also crowded with similar narratives from coffee companies that discuss their partnerships with producers. Producers would thus have to be exceedingly clear on why producer-owned (or origin-owned) coffee brands are preferable to other alternatives, such as direct trade or Fairtrade. In that regard Geographical Indications (GI) can help (See Box 12).

Box 12: Geographical Indications to Build Producers' Branding

Producers and producing countries have started using Geographical Indications (GIs),[236] an intellectual property tool, to protect the reputation of their coffee origin and capture more value. In trade theory, GIs and other trademarks correct consumer information asymmetries regarding an attribute of value—the origin—as long as the information is reliable. [237]

Examples can be found in Colombia (Café de Colombia, Café de Nariño), the Dominican Republic (Café Valdesia), Guinea (Ziama–Macenta coffee), Jamaica (Blue Mountain), Ethiopia (see below), and Mexico (Café Veracruz)).

GIs support long-term differentiation and origin branding, which allows producers to access a higher value for origin products while also avoiding appropriation of geographical names by other entities not linked to the area. As such, in some areas, coffee is following the same path as cheese, wines, or spirits that have used GIs "to avoid unfair competition and free-riding of their quality reputation, empowering local producers to define the specific rules for using the origin label."[238]

One example comes from Ethiopia, where the government launched the Ethiopian Coffee Trademarking and Licensing Initiative in 2004 for three coffee origins producing high quality beans: Sidama, Yirgacheffe, and Harar.[239] The government has subsequently offered licensing agreements to importers, roasters, and distributors; licensees are expected to enter into a brand management strategy and promote these coffees with customers. While licensees do not pay any royalty, the Ethiopian government hopes that the brand management strategy will result in increased global demand for these origins in the specialty segment. The government also hopes to increase the farmers' share of the retail coffee price by improving their negotiating power.[240]

However, GI protection does not automatically trigger a substantial price increase or a pass-through to farmgate prices.[241] Developing and promoting GIs requires long-term efforts and strategic planning. Substantial institutional support is needed, from the government and/or producers' associations, to ensure careful and consistent quality control, brand management, and marketing strategies that, over time, can help producers capture more value.[242]

Three broad possibilities for (more) direct-to-consumer sales include:

- **Direct-to-consumer sales of high-quality green coffee beans**, which consumers then roast themselves. This removes the need for producers to roast the beans, but does require that producers can guarantee a high quality level of beans, as well as proper preparation and packaging to ensure that there is not significant quality loss in transit. This will always be a niche market; most consumers are not in the habit of roasting their own beans, and the larger trend is instead a growing reliance on capsules and pods that make coffee preparation easier rather than harder. Yet some coffee enthusiasts already roast at home,[243] and producers could seek to increase this segment of consumers, and to capitalize on it through direct sales, potentially through producer-owned online platforms that could aggregate offerings. For this strategy, producers might be competing primarily on quality, with their narrative and the direct link to the producer as a compelling secondary motivation for consumers.
- **Direct-to-consumer sales of high-quality roasted coffee beans.** Selling roasted beans requires producers either to roast the beans themselves or cooperatively, or to work with a roaster that is paid to roast and package the beans. While roasting at the farm level might not be economically viable, roasting cooperatively is more feasible, either at the level of a cooperative in country, or through a producer-owned vertically integrated company such as Pachamama Coffee (Box 13). Although roasting adds value to coffee beans, poor roasting can ruin the product, and producers should only undertake roasting if it can be done well.

Box 13: Pachamama Coffee, a Producer-Owned Vertically Integrated Company

Pachamama Coffee is owned by participating cooperatives, and its board of representatives is composed of cooperative representatives. This gives the cooperatives control of company strategy, and a path towards financial independence.[244] There are five member cooperatives within Pachamama, based in Ethiopia, Guatemala, Mexico, Nicaragua, and Peru. All the cooperatives specialize in producing certified organic coffee. Farmers are paid above the market price for green coffee.[245] The cooperatives then are allocated a share of the profits, based on how much they sell. The board votes on how to allocate profits, which may be retained to invest in Pachamama projects.[246] Pachamama offers online subscriptions direct to consumers, runs two cafés in California, and has retail and wholesale relationships with other companies. This farmer-owned and farmer-governed model shifts some new business risks onto farmers, but also moves farmers from price-takers to price-setters, who control value addition and who thus capture significantly more of the profits than in most coffee value chains.

One alternative to producer-led roasting is paying an external reputable roaster. In such a relationship, the roaster serves the producer in the same way that it otherwise serves as a private label roaster for a retail brand: it is paid for its service, but is not otherwise seeking to add or capture value derived from branding or intangible aspects. These external roasters could be in origin countries or in consuming countries. Roasters in origin countries may be cheaper and easier for producers to work with; some roasters in origin countries are also willing to package and export for producers.[247] Roasters in consuming countries are another option to explore; working with them can alleviate concerns (likely overwrought) about freshness, while also taking advantage of the overcapacity of roasters in some consuming markets, such as the United States.[248] Some mid-sized farms already roast their coffee in coffee-consuming countries and handle their own sales. For example, Unleashed Coffee is a Brazilian coffee estate that roasts its coffee in the United States and sells its coffee directly to consumers online.[249]

A variation of this is for producers to partner with innovative roasting and retailing companies that put producers at the forefront of the business (see Thrive Farmers in Box 14, Moyee Coffee in Box 15). While these opportunities are currently limited, producer associations or other institutional actors could consider how to support scale up of those models, or how to replicate them for other producing locations.

Box 14: Consignment Service for Producers

Thrive Farmers provides a revenue-sharing model that essentially operates as a consignment service for producers, thereby significantly increasing the producer's share of the final retail price. Thrive Farmers generally requires producers to pay for the roasting and exporting of their coffee. It then pays producers after their coffee has been sold to retailers, giving 50% of the sale price to the producer.[250] Sometimes, Thrive Farmers sells coffee to other roasters; when it does so, it pays the producers 75% of the sale price. Farmers must wait 6-12 months to be paid in this system, which is not always feasible for smallholders.[251]

If enough trust and transparency exist, similar consignment approaches could potentially be integrated into the operations of existing specialty coffee companies. One leading specialty company, for example, has used a modified consignment model with one supplier: paying an initial lower price upfront, and then providing an additional payment based on how the coffee sold.[252]

For this direct-to-consumer strategy, there may be two distinct but overlapping categories in which producers would be competing with existing specialty coffee companies: quality and social responsibility. While most specialty coffees have a social responsibility narrative, quality-oriented consumers care less about social responsibility and more about taste and brand-related intangibles. Producers seeking to compete on quality will need to find ways to have an attractive brand offering that speaks to this segment of the market[253]—although coffee consumers also behave differently throughout the day, appreciating different qualities depending on the hour.[254] In addition, the willingness of some consumers to purchase coffee based more on its social responsibility narrative than its quality, combined with traceability technologies such as blockchain (see Moyee in Box 15), opens up additional opportunities for producers, many of whom produce coffee at a range of quality levels. Working collectively, producers might then be able to find ways to sell both higher-quality coffees and lesser-quality coffees through different avenues or producer-owned brands.

Box 15: Moyee Coffee Using Blockchain for Traceability

Moyee Coffee is an Ethiopian and Dutch coffee growing, roasting, and retailing company that uses blockchain and geotagging to trace the transactions within its supply chain. When it buys directly from cooperatives, Moyee assigns unique IDs to each farmer and pays farmers via mobile phones. Customers can access this information by scanning the QR code on their package of coffee.[255] When buying directly, Moyee pays a 20% premium to farmers.[256] Moyee also buys coffee from the Ethiopian Commodity Exchange; when it does so, it reserves a 20% premium that is then allocated to farmer training.[257] Moyee Coffee sells to institutions,[258] but also directly to consumers through the Internet.[259]

Direct-to-consumer sales of commercial-grade roasted coffee beans. As with the approach above, this requires either producer-led roasting or securing the services of private label roasters. Rather than competing on quality, or relying on the producer-origin narrative, however, producers of commercial-grade coffee would compete on price, seeking to reach price-sensitive consumers who like the ease of purchasing coffee online and who are willing to try a new brand or source of coffee. Because the cheapest coffee brands have a relatively lower profit margin compared to specialty and quasi-specialty brands, producers also would have a lower profit margin when competing on price than on quality. Despite this, and assuming that they are able to find ways to efficiently move coffee to consumers (discussed below), producers would still receive a higher share of the ultimate retail price paid by consumers. Profitability and economic viability would require sufficient volume.

Of the three strategies noted here, this third strategy is the most different from what has been tried in the past. The analogy is what Chinese manufacturers have been able to do given the existence of Amazon: they can now cut out the middlemen, and sell directly to American consumers. However, Amazon's infrastructure has facilitated Chinese manufacturers' ability to do this, both through support in shipping[260] and then through fulfillment once goods reach Amazon warehouses.[261] Coffee producers would similarly need significant institutional support that aggregates products and ensures some baseline consistency of quality, lowers the costs of transport, and helps with navigating export and import requirements and any legal obligations. [262]

While absolutely critical for the third strategy above, institutional support would also help to scale the opportunities for producers to take advantage of other direct-to-consumer possibilities. Economies of scale are likely necessary to make the administrative and logistical aspects feasible for many producers. Some of the institutional support needed could potentially be undertaken by producer associations—for example, the FNC supports Colombian producers that have found buyers in particular countries by arranging the logistics and shipping for a fee. Aside from taking these roles on themselves, producer associations could also help to aggregate producers for economies of scale, and to identify and negotiate better rates with existing entities and companies that could provide necessary services, such as transport or distribution.

Producer associations could also connect with the electronic World Trade Platform (eWTP) initiative, which aims to integrate local small and medium-sized enterprises (SMEs) into global value chains by addressing the barriers commonly faced by SMEs in international trade, such as access to information regarding export opportunities, access to trade finance, and logistics costs.[263] This initiative was jointly created by the World Trade Organization, the World Economic Forum, and the Electronic World Trade Platform in 2016, and it is led by China's Alibaba e-trade platform.[264] Rwanda was the first African country to join the initiative in October 2018; Rwandan coffee is now sold on Alibaba's Tsmall international marketplace.[265] Participation in the eWTP initiative can make possible an endeavor that would otherwise be prohibitively expensive. It is usually expensive for an SME to open a section on Alibaba (foreign companies, qualified as gold members, must provide deposits of up to $25,000, pay annual seller fees up to $10,000, and a royalty commission of 2-5% on each sale).[266] In the agreement between the Rwanda Government and Alibaba, however, Rwandan coffee roasters—often cooperatives selling quality coffee[267]—are not currently charged these fees for selling on the platform as per the guidelines of the eWTP initiative.[268]

Although currently niche, the models discussed above, many of which have already shown proof of concept, have potential to scale or replicate with sustained institutional support. The design of National Coffee Sustainability Plans, discussed above, offer one opportunity for relevant government institutions, producers associations, and other local stakeholders to assess the opportunities for producers within the country to capture more of the final retail price, including by taking advantage of technology to get closer to the end consumer.

Conclusion

Under current and future market conditions, which include persistent low prices, rising input costs, and devastating climate change effects, even efficient producers will struggle to remain viable, and the SDG gap in coffee-producing regions will grow. Without sustained collective action, and without strategic national-level planning and investments, more producers will be thrown into or remain in extreme poverty, while increasingly consolidated origins will result in heightened supply risks. The prosperity of the coffee sector relies on healthy and viable farmers, including smallholders; this business-as-usual scenario is not sustainable for them or for the industry.

Coffee sector actors have acknowledged these deep sustainability concerns, particularly in light of the ongoing price crisis and impending climate crisis. Multiple calls for global collective action on prices have been made, including by the World Coffee Producers Forum since its creation in 2017, as well as by the International Coffee Council, which mandated the ICO to address low coffee prices by launching a sector-wide dialogue to identify transformational multi-stakeholder solutions to be implemented by committed ICO members.[297] We suggest National Coffee Sustainability Plans, to support strategic planning and investment that account for differentiated producer needs and future prospects given climate impacts. We suggest a Global Coffee Fund, as a transformational and multi-stakeholder mechanism that embodies the shared responsibility of public and private actors in achieving sustainability in coffee production and in coffee-producing regions. And we suggest serious exploration of other ways to increase producer profits that take advantage of recent transformations relevant to the coffee sector (in particular, high consolidation of the industry and mainstreaming of new technologies), including through a minimum price and through business models that allow producers to capture more of the final retail price. Taken together, these strategies provide ambitious yet achievable pathways for making coffee truly sustainable.

Photo by Mikesh Kaos on Unsplash

Appendices

1. Changing Climate

Z-Score Deviations

In Figure 23, we normalize present and future temperature ranges to show how regions across the tropics are moving outside of their historical range. The normalization method is to convert each region's temperatures into z-scores:

$$ZScore = (T - Mean(T_0) \ / SD(T_0)$$

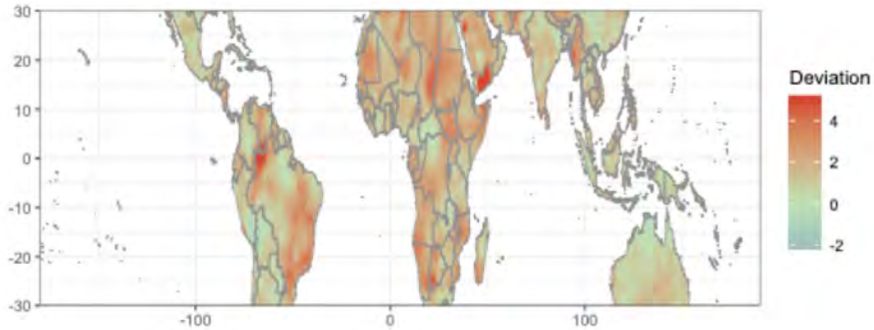
Where $Mean(T_0)$ is the average annual temperature from 1900 - 1960 in each region, and $SD(T_0)$ is the standard deviation across those temperatures. Under this transformation, the z-scores of the historical period conform approximately to a normal distribution, with mean 0 and standard deviation 1. Any future average temperature can be compared to this distribution, where temperatures with z-scores greater than 1 occur 16% of the time under the historical distribution, values greater than 1.96 occur 2.5% of the time, and values greater than 2.33 occur 1% of the time.

Z-scores in the recent period are computed from an average from 1999 – 2018, representing a climatic average around 2010 for each region, and z-scores in 2050 are computed using the climatological mean temperature from GISTEMP.[298] The spatial distribution of these z-score values is shown on the next page.

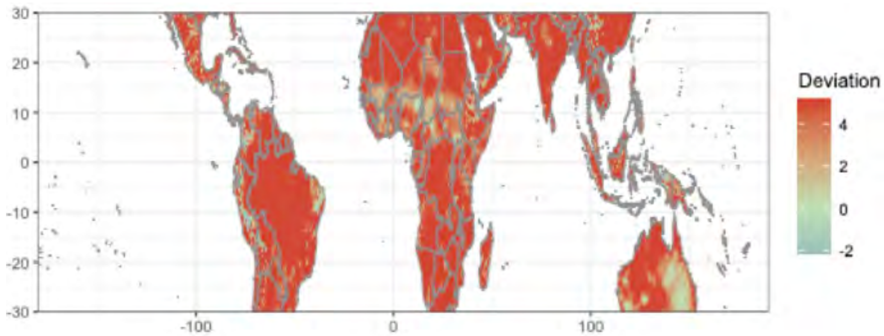
Photo by Christian Joudrey on Unsplash

Deviation from historical range in recent years and by 2050. These maps correspond to the distributions in Figure 23, showing where deviations from the historical distributions are high. Z-score deviations are clipped at 4 (above the 99.99th percentile) in the figures.

Recent Z-score deviations in temperatures (around 2010)



Z-score deviations predicted in 2050

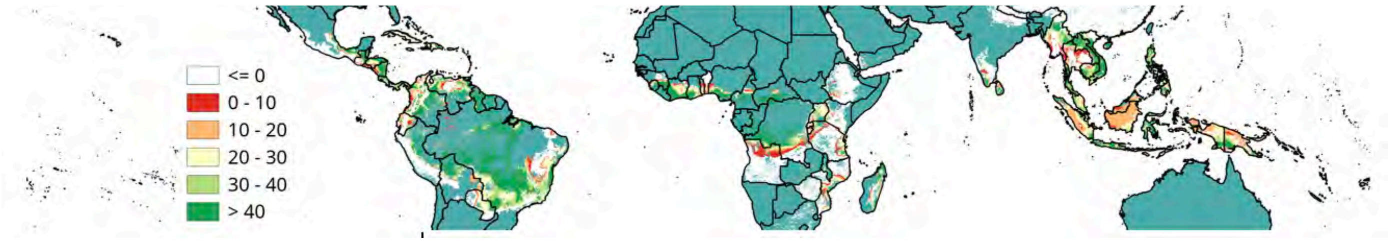


Shifting Suitability

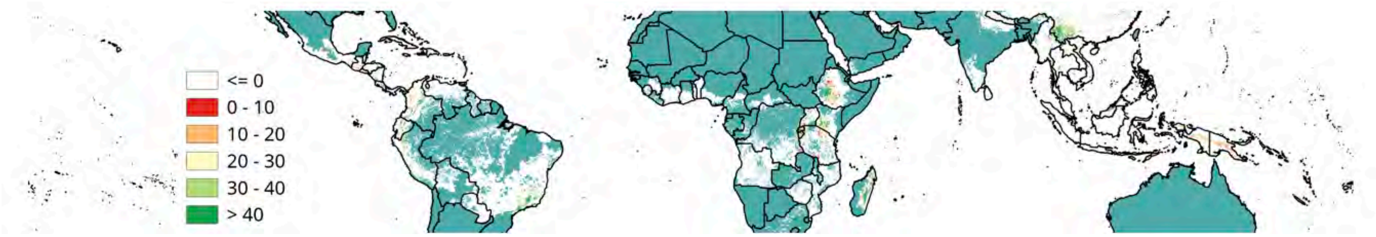
To analyze the loss of suitable land, we use the Global Agro-Ecological Zone (GAEZ) project, version 3.0, which provides a combined climate-related suitability constraint as a percentage from 0 – 100%. We treat values below 50% as unsuitable. We use a rainfed, intermediate inputs scenario for both the baseline (1961 – 1990) and climate change (2050, Hadley3 model, A1 scenario) periods. These suitability ranges can be extended considerably with the application of improved management. The resulting suitability levels are shown in the adjacent maps.

Spatial suitability values used to determine county-level area suitable. Suitability values below 50% are treated as 0, and other suitability levels are reduced by 50%.

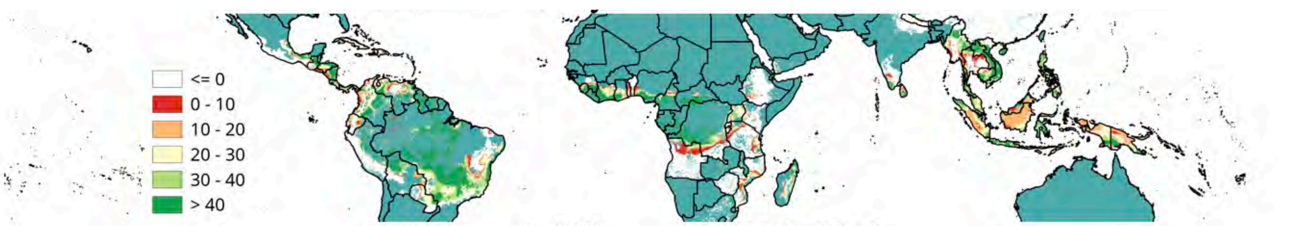
Arabica suitability over 50% at baseline



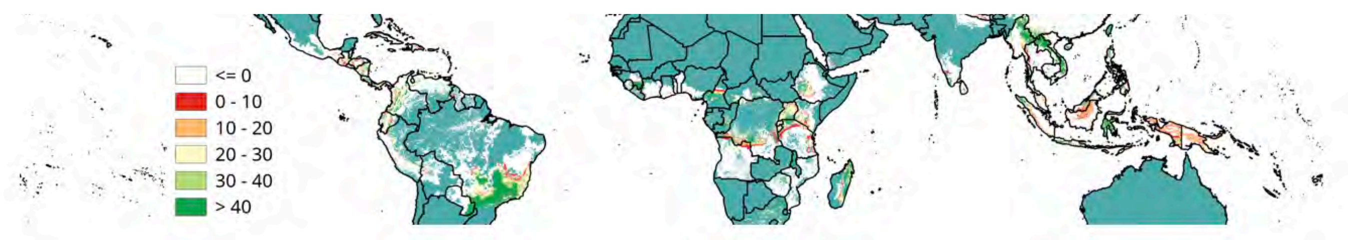
Arabica suitability over 50% in 2050



Robusta suitability over 50% at baseline



Robusta suitability over 50% in 2050



The total suitable land is calculated as follows:

$$Area = \sum 2\,(Suitability - 50\%)\ GridCellArea$$

where the sum is taken over grid cells that are neither forests nor wetlands. That is, if suitability in an area is 51%, then 2% of the land area is counted toward the country-level suitable land total. Forests and wetlands are excluded because conversion of these land use types to coffee production could undermine climate change and sustainability goals. Land cover is from the USGS EROS LandCover GLCCDB version 2.0 database for the year 2000. This formulation provides an indicative measure of suitable land, but the actual relationship between suitability levels and suitable land areas is not grounded in empirical analysis.

2. Changes in Coffee Yields

Updates to the coffee supply database

We build upon the coffee supply database developed for the Earth Institute, which collects production records from agricultural ministries and coffee production regions from grey literature. We rely on comprehensive production records for administrative regions, rather than individual farms, because they provide a less biased representation of how coffee-growing is affected by climate change. The production records are summarized in the adjcacent table.

Summary of the coffee production database records. The trend is computed for yields from FAO records, which generally span 1980 - 2017, and no records before 1980 are used because of the limitation of the weather data. The standard error is on the trend estimate, and represents the degree of variability in the yields.

	# Regions	Years	Area (1k Ha)	Yield (MT/Ha)	Trend (%/yr)	Std. Err. (%/yr)
Brazil	2749	1980 - 2017	1803.57	0.77	2.78%	(0.23%)***
Indonesia	10	1980 - 2017*	1253.80	0.50	-0.15%	(0.05%)***
Colombia	21	1980 - 2017*	798.36	0.83	0.38%	(0.19%)**
Ethiopia	1	1993 - 2017	694.33	0.71	-0.38%	(0.23%)
Vietnam	18	2011 - 2014†	641.70	1.77	4.97%	(0.43%)***
Uganda	1	1980 - 2017	385.30	0.64	-0.18%	(0.2%)
India	12	2012 - 2016†	347.00	0.64	0.3%	(0.17%)*
Guatemala	1	1980 - 2017	278.23	0.90	0.7%	(0.14%)***
Honduras	175	2002 - 2010†	196.54	0.70	1.05%	(0.1%)***
Others	55	1980 - 2017	1148.25	0.89	0.02%	(0.16%)

*: The regional breakdown for Indonesia and Brazil are only used for targetting the coffee production in space; Country-level FAO data is used for analysis.
†: The timeseries for Vietnam, India, and Honduras are shorter than available FAO data, so FAO data is substituted for the periods before these begin.

Understanding the risks of climate change for coffee production requires matching it to high-resolution weather. For this, we extend the Coffee Production database with high resolution cultivation maps for Bolivia, Burundi, China, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Hawaii, Ivory Coast, Kenya, Laos, Mexico, Nicaragua, Nigeria, Papua New Guinea, Peru, Philippines, Tanzania, Uganda, and Yemen.

The statistical production models developed here relate how changes in weather result in proportional changes in yields. This proportional relationship uses the logarithm of yields as the dependent variable:

$$ln\,(Y_{pt}) = f(W_{pt}) + \epsilon_{pt}$$

where p indexes farms and ptis an error term. This relationship is assumed to hold most closely at high resolution; theoretically, at the scale of each individual coffee tree. Because we only observe region-average yields, it is necessary to translate this model to the regional scale.

$$ln\,(Y_{it}) = \frac{1}{n}\sum_{p\in P(i)} Y_{pt} = \frac{1}{n}\sum_{p\in P(i)} exp\,(f(W_{pt}) + \epsilon_{pt})$$
$$\approx \frac{1}{n}\max_{p\in P(i)} exp\,(f(W_{pt}) + \epsilon_{pt})$$

This uses what is called the LogSumExp approximation, and argues that the weather at the most productive location is the most effective predictor for the entire region's yield (more predictive, for example, than the average weather across the region). With this insight, we use coffee cultivation maps to identify a location of maximum cultivation within each country or sub-country region for which we have production data. For sub-country regions without cultivation maps, we use the centroid of the region. For countries without cultivation maps, we identify the point of maximum coffee suitability from GAEZ. These points are shown below.

Locations of observed coffee production data. Both the coffee production data (production, harvested area, and planted area by variety) are drawn from multiple sources, and the points in many cases represent the geographically weighted centroid of high resolution coffee production maps from multiple sources. The database includes 2983 sub-country regions from Brazil, India, Indonesia, Vietnam, Colombia, and Honduras; country data from 59 other countries; and years ranging from 1980 to 2017 matched to weather from ERA-Interim.

Two major coffee-producing countries are missing from our dataset, because of unresolved data inconsistencies within our analysis: Peru and Tanzania. We apologize for this omission.

Weather Data

For this project, we use data from ERA-Interim (ERA-I), a reanalysis product that combines station and satellite data with meteorological modeling to construct a consistent, gridded dataset.[299] The ERA-I data is available at a 0.75° resolution at a daily scale. To improve the resolution, we use the CHELSEA spatial downscaling dataset, available at a 30 arc-second resolution, monthly for precipitation, minimum temperature, maximum temperature, and mean temperature.[300] To maintain the daily resolution, we apply monthly differences from the grid-cell mean to each daily observation for these four variables.

Finally, we use these data to develop a regional dataset of the following variables:

- Average temperature at 2m by month [K]
- Average maximum temperature at 2m by month [K]
- Average minimum temperature at 2m by month [K]
- Average dewpoint at 2m by month [K]
- Dewpoint at 2m during minimum temperature by month [K]
- Dewpoint at 2m during maximum temperature by month [K]
- Top soil temperature by month [K]
- Top soil moisture by month [m^3 / m^3]
- Wind speed at 2 m by month [m/s]
- Photosynthetically-active solar radiation at surface [J / m^2]
- Precipitation runoff by month [m]
- Total precipitation by month [m]
- Exceedence degree-days by threshold and month [C day]
- Frost degree-days (below 0 C) by month [C day]

We extracted this data at point locations for the year of the reported yield and for the previous year, at a monthly level, to feed into a cross-validation model selection exercise to identify the most effective predictors.

Weather Emulation

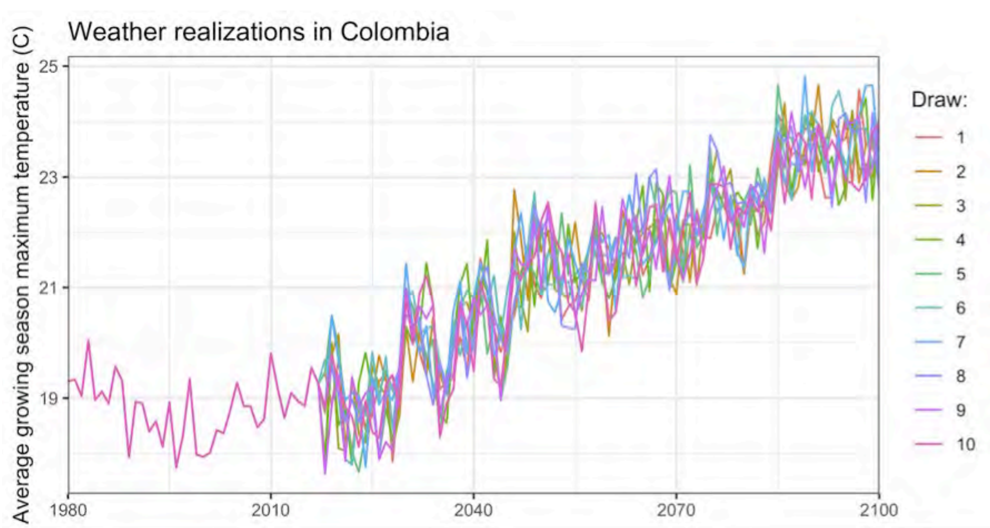
We use a variety of weather variables to predict coffee yields, available from the ERA-Interim weather reanalysis dataset. Many of these variables are not reliably predicted by global climate models, and MIROC-ESM-CHEM GCM data requires downscaling to represent daily variation (which we use for precipitation and growing degree-days) and specific locations.

To translate GCM results into high-resolution weather appropriate for predicting yields, we apply GCM-driven adjustments to historical weather, as follows:

1. We use the observational data to construct linear spline functions that relate each weather variable to average annual temperature. We prefer this approach to using projections for other weather variables provided by the GCMs because of the inconsistencies between projected and historically observed weather for precipitation and some other variables. We construct the linear splines using all observed data, producing a set of functions $f_v(T)$, indexed by weather variable v.
2. In each future year, we compute each location's adjusted annual average temperature, as $\hat{T}_{igt} = T_{i0} + (T_{igt} - T_{ig0})$, where T_{i0} is the average temperature for region i in the observational data over all years after 2005 (when most GCMs start); T_{igt} is GCM g's predicted temperature for the grid cell covering region i in future year t; and T_{ig0} is GCM g's average temperature for that grid cell over the same years as used to compute T_{i0}.
3. We select a random year, s, upon which the temperature changes will be applied.
4. We evaluate the spline functions at $\hat{T}_{igt}$ and T_{i0}, and determine adjust the weather variables using the difference: $v_{it} = v_{is} + f_v(\hat{T}_{igt}) - f_v(T_{i0})$.

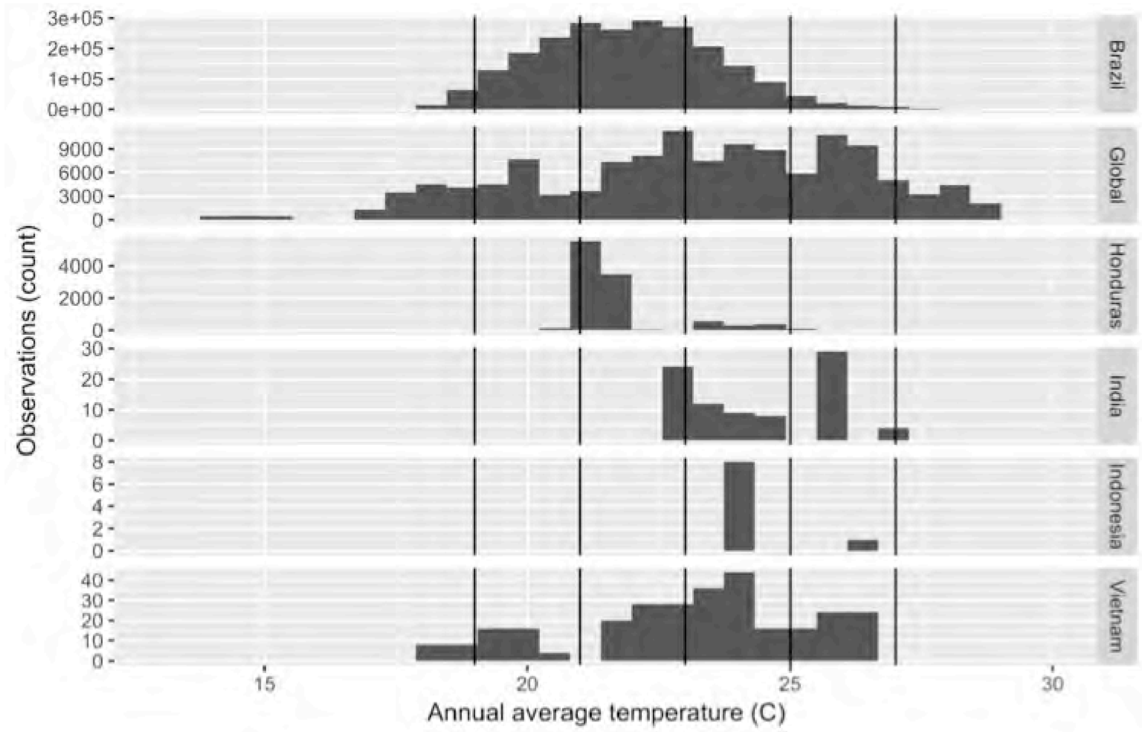
For an example of how this process works, consider a projection for average temperatures, for which $f_v(T) = \hat{T}$. We consider a region in Colombia and make 10 independent draws, performing the rest of the operations:

Ten random realizations of the weather at a location in Colombia. Temperatures continue to increase according to the anomalies inferred from the MIROC-ESM-CHEM model.



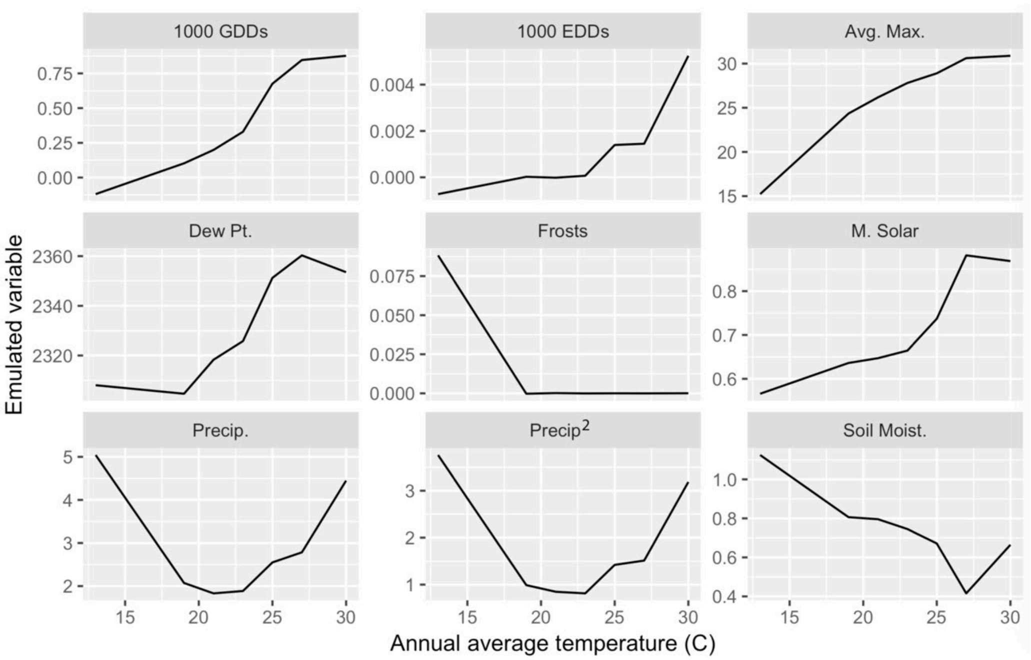
The linear splines use knots at 19 °C, 21 °C, 23 °C, 25 °C, and 27 °C. These are chosen because we have a distribution of temperatures such that no single region dominates any spline segment.

Distribution of annual average temperatures by region. Brazil, Honduras, India, Indonesia, and Vietnam are split out because we have subnational data for these, while Global includes all other countries. The vertical lines represent knot locations, which generally fall within, rather than around, the distributions.



The resulting relationships between average temperature and weather variables $(fv\ \ (T))$ are shown in the figure below. The relationships are generally as expected: GDDs increase gradually, until about 27 °C when the upper limit begins to cap them. KDDs are 0 until 23 °C, at which point some daily highs exceed the 34 °C limit. Precipitation measures display a U-shaped relationship, with higher rainfall at low temperatures and high temperatures.

Estimated linear spline relationships between annual temperature and the 9 variables used in yield estimation. The weather variables reflect the predictors chosen by the cross-validation exercise below, recorded within the seasonal limits identified there.



Cross Validation

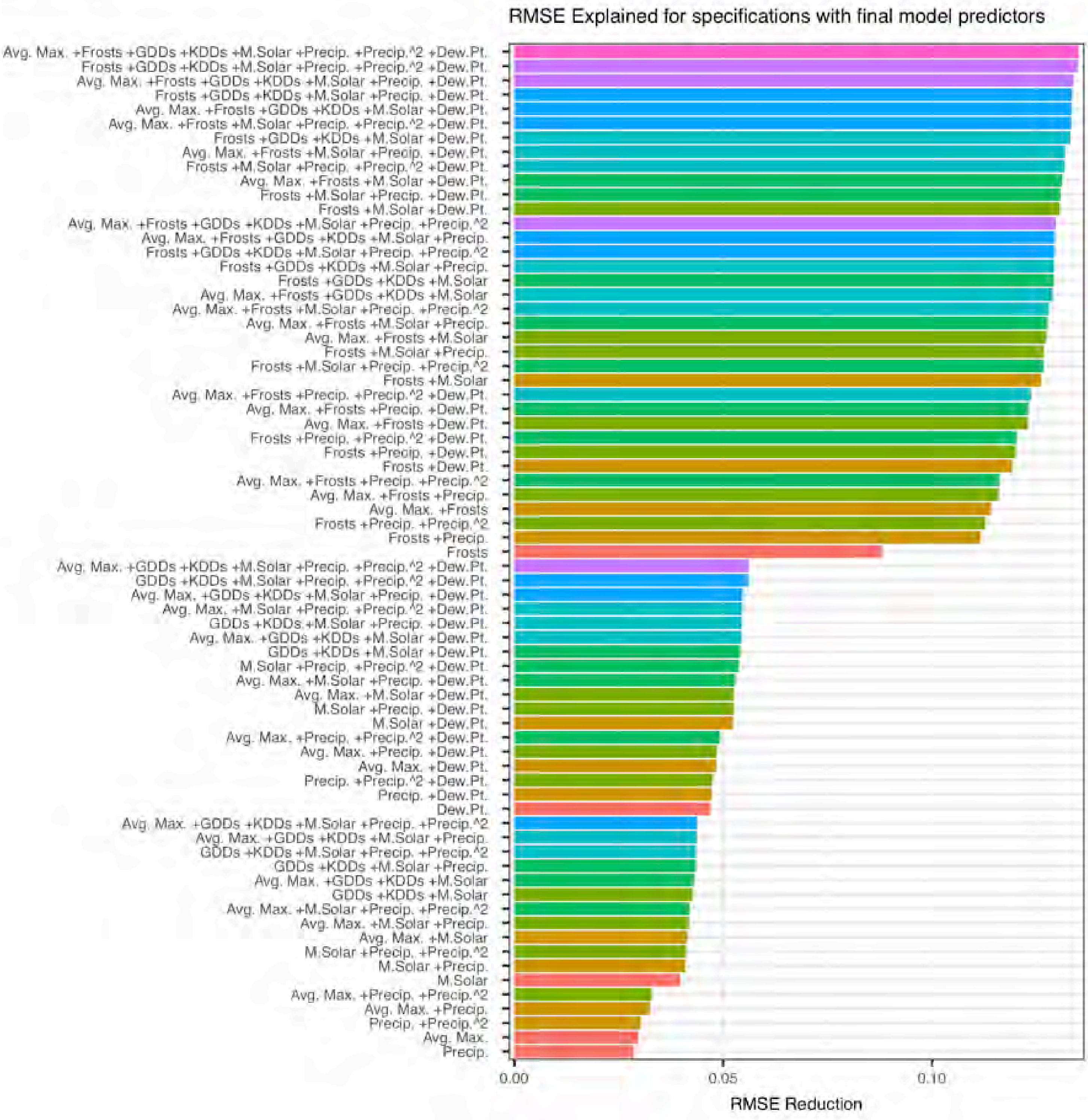
Identifying the weather variables which most effectively predict yields requires a careful screening process. To do this, we use a technique called "cross-validation", where the model is successively fit to a training dataset, and then applied to a test dataset to evaluate its ability to predict out-of-sample yields. For dividing the data into training and testing datasets, we define a collection of subsets of the data. For countries in which we have sub-country data, we define a different subset of reach state (ADM1 region). For other countries, each country is its own data subset. Then, for each possible model, we perform this test by "leaving out" each subset, using it as the test data, and fitting the model to the remaining subsets. The metric for evaluating datasets is the portion of the RSME explained, defined as the root-mean-squared predicted yield. We are interested in models that maximize this metric.

To filter possible sets of predictors, we impose the following constraints:

- Monthly predictors will be accumulated over "month spans" within each year. These month spans will be considered relative to the month of harvest, which is taken as an average of the major harvesting period for each country. For example, the month span used for precipitation might be accumulated across the precipitation observed from 7 months before the harvest month to the month of the harvest. Month spans may extend from 12 months before the harvest month to the harvest month.
- Exceedance degree-days are translated into "growing degree-days" (GDDs) and "extreme degree-days" (EDDs). In each case, two thresholds are chosen: a low threshold and a high threshold. Below the low threshold, degree-days are not included in either predictor; between the low and high threshold, they are only included in the GDD predictor; above the high threshold, the GDD predictor for that day takes its maximum value and the additional degree-days are included in the EDD predictor. Only the following threshold points are considered: 0 °C, 10 °C, 20 °C, 28 °C, 30 °C, 32 °C, and 34 °C.
- Precipitation may be included a single term or a quadratic pair of terms (but not only the squared term of the quadratic); EDDs may only be included if GDDs are also included.

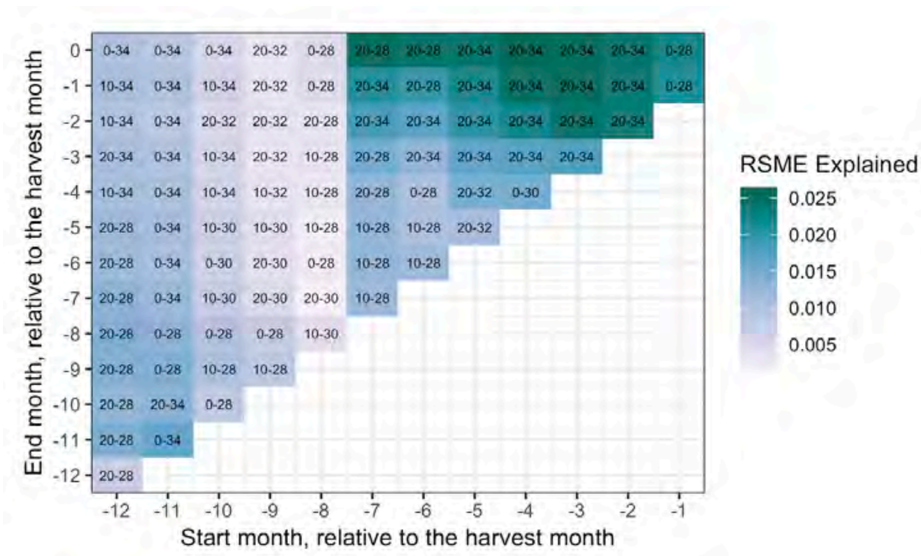
A subset of the comparison between specifications is shown below, for only those specifications that included variables ultimately included in the final result.

RMSE Explained for specifications that contain predictors selected in the final model. In general, specifications with more predictors are preferred (bars colored by number of terms).



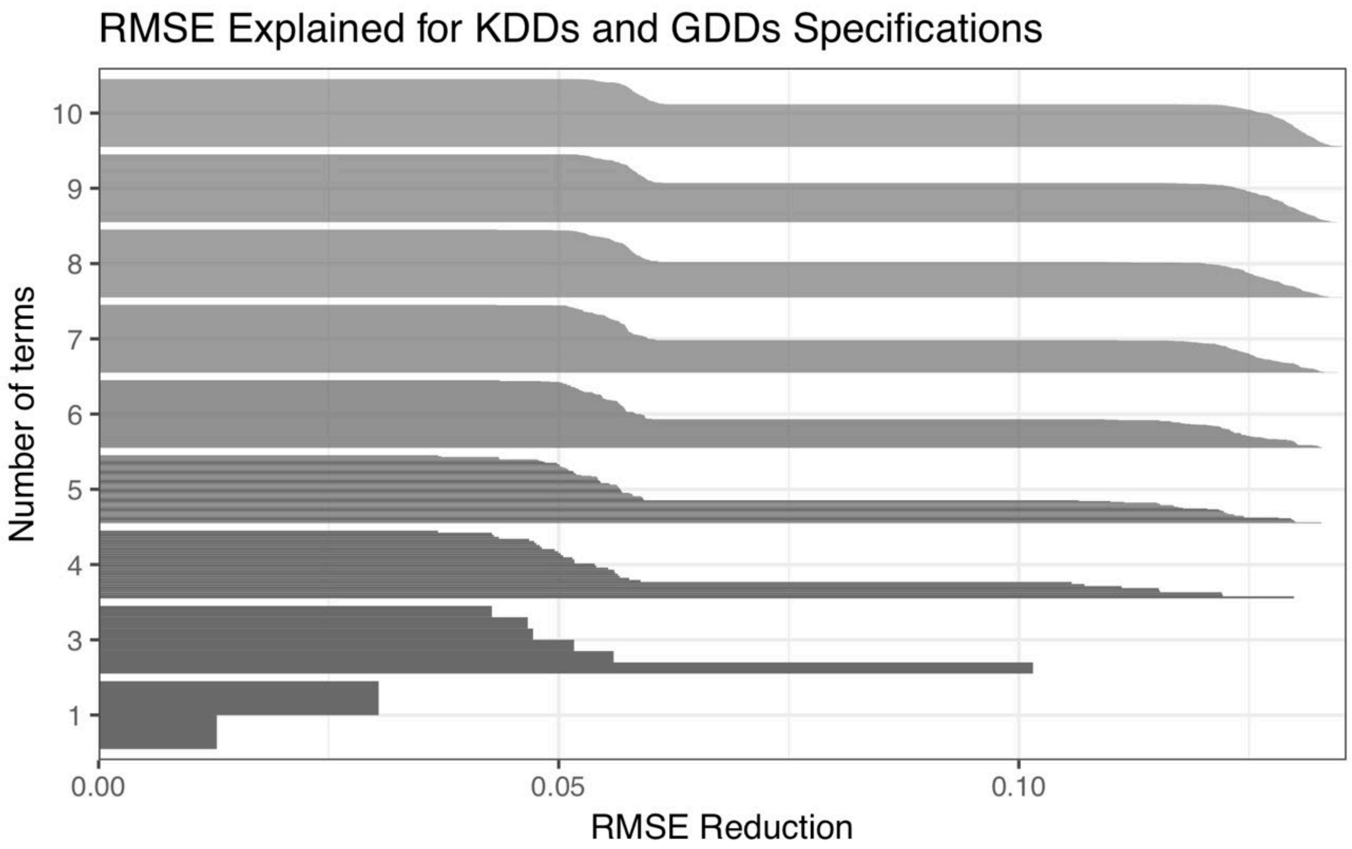
This set of assumptions applied to the predictors above results in $(1+91)^{12}(1+2\bullet92)(1+2\bullet7!/2!5!) \approx 3e27$ combinations. To reduce this search space, we first search for the most predictive month span for each predictor individually and for each predictor in combination with the possible GDD and EDD spans. Only about 4000 possibilities need to be considered for each of these cases. As an example, a plot showing the relative effectiveness of different month spans for only GDD and EDD is shown below.

RMSE explained for different model specifications including only the GDD and EDD coefficients. The best temperature thresholds for each month span are identified, and shown as the text in each box. For each month span, specifications with only GDD, only EDD, and both are tried; in all cases, the specification with both has the maximum RMSE explained, and is shown.



Next, a cross validation is performed where the set of final predictors is chosen from the optimal predictors identified above. Each predictor (such as solar radiation) is represented in this choice-set in two forms: by the month span that was found most predictive when it was selected in isolation, and by the month span that was to be most predictive when combined with GDD and EDD predictors. GDD and EDD predictors are included both using the temperature and month spans that were identified when these were considered on their own, and in the forms identified when combined with each of the other predictors. This results in the testing of about 2 million combinations. Only final specifications that included a single GDD-EDD predictor combination where considered.

We find that more terms are beneficial until about 9 terms. The graph below shows the range of RMSE explained values for all specifications that have a given number of terms. Each has a characteristic “hump” shape, representing the greater predictive power associated with, in particular, frosts and precipitation.


RMSE Explained for KDDs and GDDs Specifications
Number of terms
10
9
8
7
6
5
4
3
1
0.00
0.05
0.10
RMSE Reduction

The final specification is:

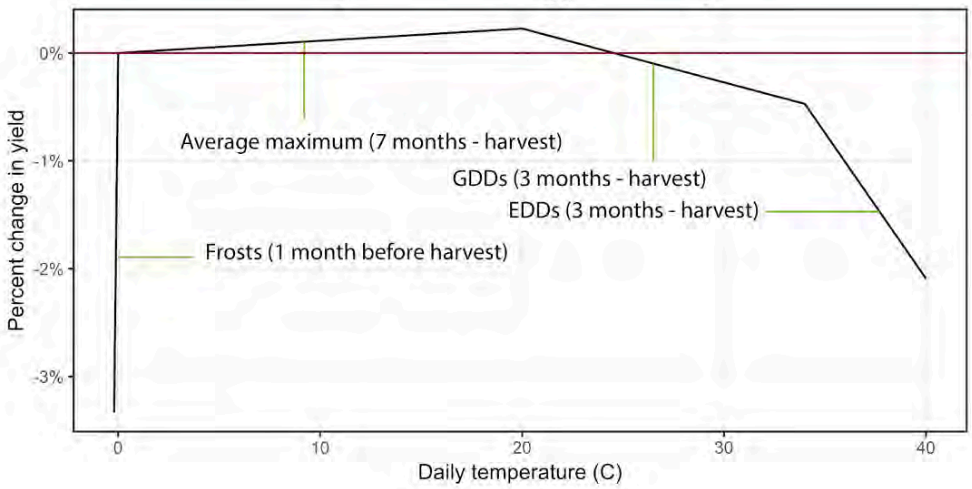
$$\ln(\bar{Yield_{it}}) = \beta_1 TMax_{it} + \beta_2 Frost_{it} + \beta_3 SoilMoisture_{it} + \beta_4 GDDs_{it} + \beta_5 KDDs_{it} + \beta_6 Solar_{it} + \beta_7 Prec_{it} + \beta_8 Prec^2_{it} + \beta_9 DewPt_{it} + CubicSpline_{c(i)}(t) + \alpha_i + \gamma_t + \epsilon_{it}$$

where maximum temperature and dew point are averaged over the 7 months prior to harvest; top soil moisture is averaged over the 2 months prior to harvest; GDDs and EDDs are totaled over the 3 months prior to harvest with a temperature range from 20 °C to 34 °C; photosynthetically-active solar radiation is averaged for the 3 months prior to harvest; precipitation is totaled in quadrative form for the 7 months prior to harvest; and frost degree-days are applied from 1 month prior to harvest.

The regression results are shown below:

	Dependent variable:
	Log Yield
Frosts (1m)	0.028*** (0.007)
Avg. Max. (7m - h)	0.028*** (0.007)
1000 GDDs (3m - h)	−0.613*** (0.090)
1000 EDDs (3m - h)	−2.813** (1.408)
Soil Moist. (2m - h)	−0.050 (0.073)
Precip. (7m - h)	−0.010 (0.014)
Precip.^2 (7m - h)	0.012 (0.009)
M. Solar (3m - h)	−0.352*** (0.097)
Dew Pt. (7m - h)	0.007*** (0.001)
Observations	72,248
R^2	0.620
Adjusted R^2	0.592
Residual Std. Error	0.340 (df = 67238)
Note:	*p<0.1; **p<0.05; ***p<0.01

Although individually some of the coefficient values are difficult to interpret, they combine to create a smooth response curve relating yields to temperatures.



We model the restriction of harvests when a weather shock reduces yields, and infer costs and true planted areas from this response. The basic steps in coffee production, as we model them, are shown below.

The Main Steps in Coffee Cultivation. In the first year, the farmer must plant and maintain the seedlings, and respond to any losses from adverse weather (boxes 1 - 3). Starting in year 3, the coffee plant beings producing beans, and the farmer makes a harvesting decision that ultimately results in production (boxes 4 - 6).

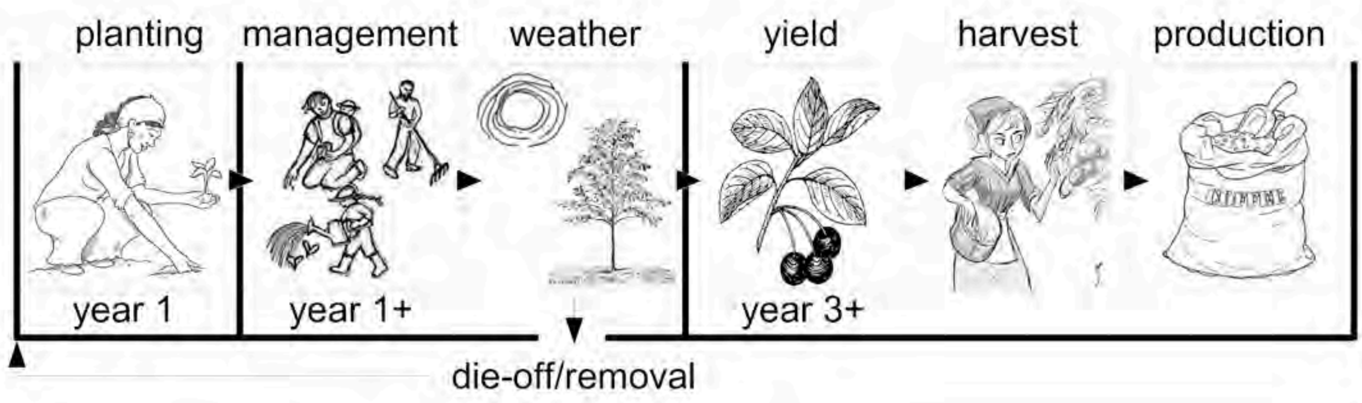
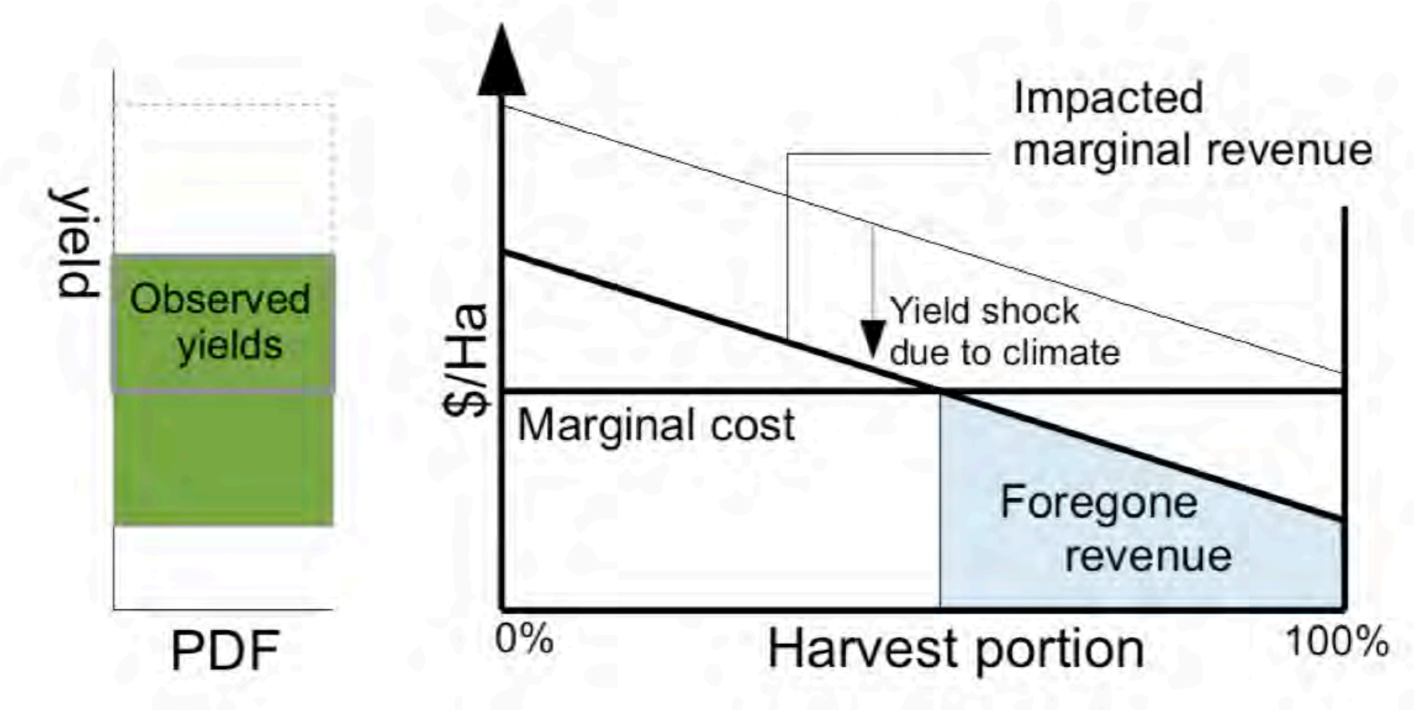


Diagram of the modeling of the harvesting decision. Harvest across the available fields down to where marginal revenue equals marginal cost. When a shock decreases the yields, farmers will decide to harvest less. This boosts observed yields, but is a limited solution.



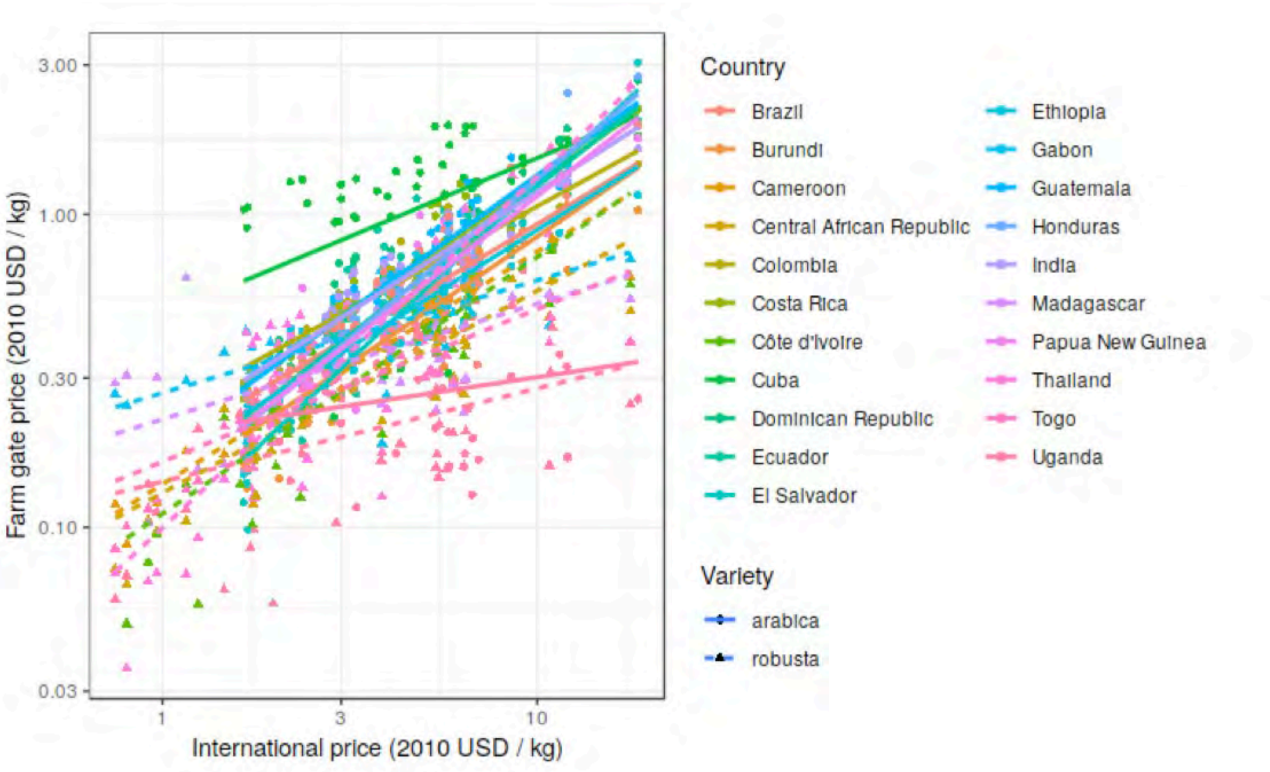
Under the full model, we can estimate the effects of each coefficient separately for Arabica and Robusta, even though these are generally not distinguished in the data. These full set of model parameters are shown below.

Parameter	Arabica		Robusta	
Yield Intercept	-16.78	(0.015)***	-16.93	(0.022)***
Yield trend	0.00	(0.003)	0.01	(0.005)**
Avg. Max. (7m - h)	0.03	(0.004)***	0.03	(0.007)***
Dew Pt. (7m - h)	0.01	(0)***	0.01	(0)***
Frosts (1m)	-0.17	(0.007)***	-0.15	(0.008)***
1000 GDDs (3m - h)	-0.60	(0.007)***	-0.60	(0.009)***
1000 EDDs (3m - h)	-3.11	(0.282)***	-2.78	(0.316)***
Precip. (7m - h)	-0.01	(0.004)**	-0.01	(0.004)**
Precip.^{2} (7m - h)	0.01	(0.002)***	0.01	(0.003)***
Soil Moist. (2m - h)	-0.03	(0.005)***	-0.04	(0.007)***
M. Solar (3m - h)	-0.35	(0.011)***	-0.35	(0.02)***
Cost of harvest	33.10	(6.522)***	34.56	(8.883)***
Range of yields	0.46	(0.031)***	0.44	(0.047)***
Harvest uncertainty	1.77	(0.023)***	1.76	(0.023)***
Production uncertainty	1.79	(0.018)***	1.77	(0.026)***

3. Changes in Planted Area

Farm Gate Price Model

We find that in (1) farmers in individual countries experience prices that are 5.5% (Robusta in the Republic of the Congo) - 46.2% (Arabica in Jamaica) of international prices in 2000; (2) for every 1% increase in international prices, farmer prices raise by 0.8% [0.79 - 0.81%]; and (3) in addition, farmer prices increase by 0.2% [0.1 - 0.3%] per year.



All prices in constant 2010 USD (not PPP adjusted).

$$ln(p_{it}) = \alpha_i + \beta\, ln(p_t) + \gamma(t - 2000) + \epsilon$$

Where p_{it} is the farm gate price in country i and year t, p_t is the international price, and is normally distributed. The expected price is then

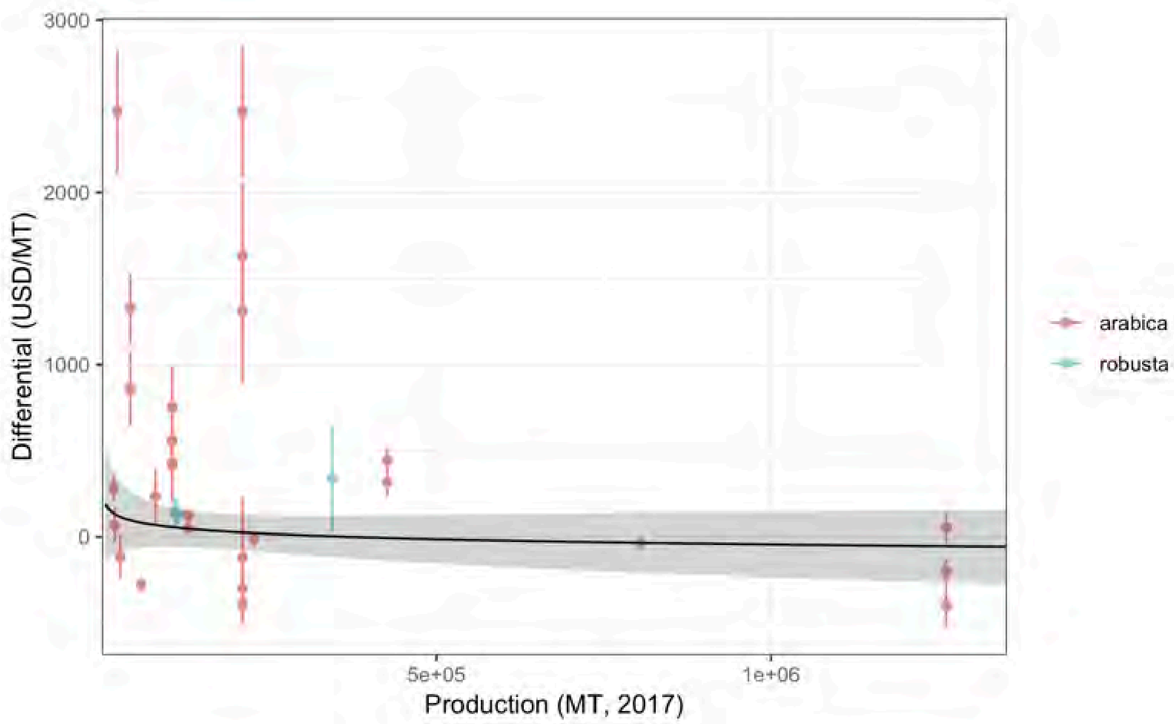
$$Ep_{it} = exp(\alpha_i + \gamma(t - 2000) + \frac{\sigma^2}{2})\, {p_t}^{\beta}$$

accounting for the residual standard error σ. The regression results are shown on the next page.

	Dependent variable:
	log(value)
log(international price)	0.798*** (0.019)
year - 2000	0.002* (0.001)
Angola - arabica	−2.273*** (0.154)
Angola - robusta	−2.056*** (0.061)
Benin - robusta	−2.402*** (0.085)
Bolivia - arabica	−1.536*** (0.072)
Brazil - arabica	−1.832*** (0.056)
Brazil - robusta	−1.679*** (0.067)
Burundi - arabica	−1.993*** (0.059)
Burundi - robusta	−2.033*** (0.140)
Cameroon - arabica	−2.098*** (0.079)
Cameroon - robusta	−2.033*** (0.059)
Central African Republic - robusta	−2.210*** (0.059)
Colombia - arabica	−1.654*** (0.056)
Congo, Dem. Rep. of - arabica	−2.080*** (0.186)
Congo, Dem. Rep. of - robusta	−2.699*** (0.073)
Congo, Rep. of - robusta	−2.964*** (0.078)
Costa Rica - arabica	−1.610*** (0.056)
Cte d'Ivoire - robusta	−2.162*** (0.054)
Cuba - arabica	−1.172*** (0.058)
Dominican Republic - arabica	−1.599*** (0.060)
Ecuador - arabica	−1.743*** (0.062)
Ecuador - robusta	−1.828*** (0.068)
El Salvador - arabica	−1.882*** (0.060)
Ethiopia - arabica	−1.901*** (0.056)
Gabon - robusta	−1.846*** (0.058)
Ghana - robusta	−2.590*** (0.101)
Guatemala - arabica	−1.591*** (0.056)
Guinea - robusta	−1.779*** (0.080)
Haiti - arabica	−2.308*** (0.074)
Honduras - arabica	−1.753*** (0.060)
India - arabica	−1.641*** (0.060)
India - robusta	−1.637*** (0.066)
Indonesia - arabica	−1.478*** (0.108)
Indonesia - robusta	−1.929*** (0.065)
Jamaica - arabica	−0.839*** (0.063)
Kenya - arabica	−1.372*** (0.062)
Madagascar - arabica	−1.747*** (0.113)
Madagascar - robusta	−2.018*** (0.059)
Malawi - arabica	−1.728*** (0.083)
Mexico - arabica	−1.480*** (0.066)
Nicaragua - arabica	−1.960*** (0.068)
Nigeria - robusta	−1.751*** (0.082)
Panama - arabica	−1.650*** (0.077)
Papua New Guinea - arabica	−1.808*** (0.061)
Papua New Guinea - robusta	−2.176*** (0.066)
Peru - arabica	−1.650*** (0.079)
Philippines - arabica	−1.773*** (0.089)
Philippines - robusta	−1.620*** (0.061)
Rwanda - arabica	−2.036*** (0.068)
Sierra Leone - robusta	−1.987*** (0.086)
Sri Lanka - arabica	−1.834*** (0.262)
Sri Lanka - robusta	−1.878*** (0.131)
Tanzania - arabica	−1.826*** (0.066)
Tanzania - robusta	−2.595*** (0.076)
Thailand - arabica	−1.506*** (0.215)
Thailand - robusta	−1.958*** (0.060)
Togo - robusta	−2.158*** (0.053)
Trinidad & Tobago - robusta	−1.383*** (0.074)
Uganda - arabica	−2.523*** (0.058)
Uganda - robusta	−2.487*** (0.057)
Venezuela - arabica	−1.407*** (0.099)
Vietnam - arabica	−2.117*** (0.370)
Vietnam - robusta	−1.555*** (0.067)
Zambia - arabica	−1.774*** (0.065)
Zimbabwe - arabica	−1.148*** (0.168)
Observations	2,005
R^2	0.892
Adjusted R^2	0.888
Residual Std. Error	0.368 (df = 1939)
F Statistic	242.349*** (df = 66; 1939)
Note:	*p<0.1; **p<0.05; ***p<0.01

Another view of these prices is in terms of the predicted portion of the international price paid at the farm gate, in the year 2000, as shown below.

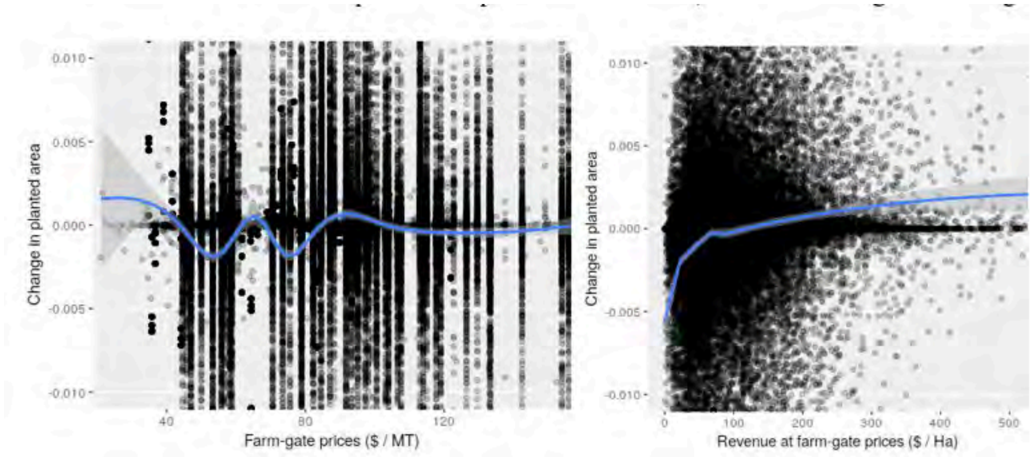
We also include a premium if the production of an area decreases significantly, and a price reduction if it increases far beyond historical levels. These premiums are based on how observed differentials vary based on the amount of coffee produced. The reported differential for both Arabica and Robusta regional varieties is shown below, along with its recent range. There is considerable variation, and we use the average change shown in the line below. This has the potential to increase prices for coffee from a given country by about $300 / MT. These are added (or subtracted) on top of price effects that are already represented in the farm gate prices, and depend only upon total production relative to the historical level.



Planting Model

Our planting model is an extension of the basic Nerlove model[301], but using revenue (as the product of prices and yields) rather than just prices as the fundamental driver of increases in land cultivation. The comparison of an estimate using price and revenue is shown below.

Observed changes in planted area, as a function of the previous year's farmgate prices (left) or revenue (right). The blue curve and confidence intervals are from a LOESS smooth fit to the data. No clear pattern is represented on the left, while one emerges on the right.

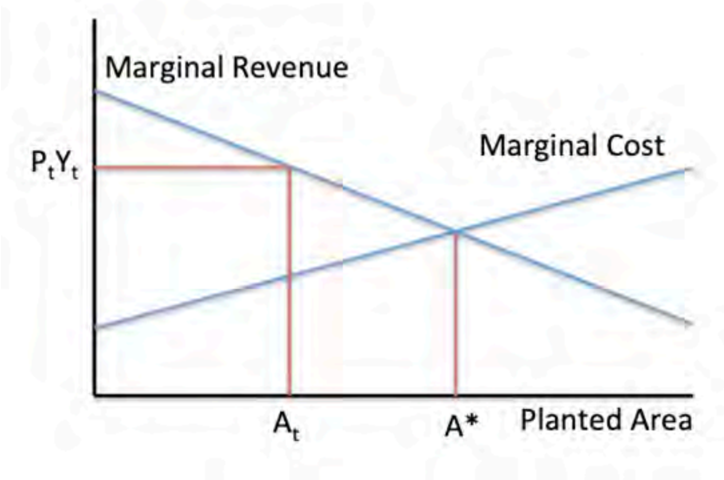


Using this insight, we develop a model that predicts increases and decreases in planted area, in response to price and yield changes. For any level of revenue, each region has a stable "optimal planted area," which is determined by the rate at which yields fall and costs climb as farmers expand beyond their prime land. Increases in expected yields or expected prices will increase this stable planted area level.

On average, the land planted for coffee within each region gradually approaches the optimal planted area. Higher revenues cause coffee to be planted more extensively and more quickly, if it is currently below the optimal level. If land planted with coffee is above the optimal level, given the current prices and yields, farmers will begin to abandon unproductive areas. In general, increases in coffee cultivation occur more slowly than decreases.

A simple theoretical diagram of the decision-making process is shown below:

Theoretical model of planting decisions. $P_t Y_t$ is the revenue in year t, under the given prices and yields. A_t is the current planted area. By finding where marginal price equals marginal cost, we can estimate the optimal planted area, A^*.



We assume that yields, and marginal revenues, decrease linearly as progressively more marginal areas are included, so that Marginal Revenue,

$$MR = \gamma(A - A_t) + P_tY_t$$

Where Y_t is the observed yield, in MT per hectare, across an observed planted area A_t in a given year. P_t is the price per MT, so that P_tY_t is the marginal revenue per hectare. Similarly, marginal costs, MC, increase linearly:

$$MC = \eta_0 + \eta_1 A$$

If all of these parameters are known, the optimal equilibrium area, from the perspective of a given year, is:

$$A^* = \frac{P_tY_t - \gamma A_t - \eta_0}{\eta_1 - \gamma}$$

Now, we assume that observed changes should approach this optimal planted area, and include both a term that is irrespective of existing planting and one that is proportional to it:

$$\Delta A = \rho_0(A^* - A_t) + \rho_1 A_t(A^* - A_t)$$

If we ignore the specific parameters, this simplifies to the structure:

$$\Delta A = \beta_0 + \beta_1 P_tY_t + \beta_2 P_tY_tA_t + \beta_3 A_t + \beta_4 {A_t}^2$$

Although no specific term in this expression is a direct price elasticity, the elasticity is equal to $y_{it} = \alpha + \beta t + \gamma_i + \delta_v + \epsilon_{it}$. We estimate this expression both using ordinary least squares (OLS) and a median quantile regression. The quantile regression is more robust to outliers. When modeled across the entire globe, the observed elasticity of price for total production is approximately 0.16 for Arabica and 0.36 for Robusta.

	Dependent variable:	
	OLS	Median Reg.
Revenue	0.00005*** (0.00002)	0.00000*** (0.00000)
Portion	−0.119 (0.108)	−0.157*** (0.0002)
Portion^2	0.003 (0.005)	0.005*** (0.00001)
Revenue · Portion	−0.001* (0.0004)	0.0003*** (0.00000)
Observations	48,941	48,941
R^2	0.157	
Adjusted R^2	0.078	
Residual Std. Error	0.028 (df = 44750)	
Note:		*p<0.1; **p<0.05; ***p<0.01

These low elasticities correspond well to estimates for other crops in the literature[302]. However, they do not reflect the ease with which some countries can expand their coffee land. For example, Brazil has multiple times as much land suitable for coffee as is currently in use, and previously had about twice as much under cultivation as now. To reflect this we allow countries to appropriate previously used land at a rate which increases as higher prices persist. Specifically, when $\Delta A > 0$, we use the expression:

$$\Delta A' = \Delta A + \min(N\Delta A, E - A)$$

where ***N*** is the number of consecutive years for which $\Delta A > 0$, excluding the current one, ***E*** is the maximum planted area for coffee in the given region, and ***A*** is the current planted land.

Production costs

We collected 180 estimates of total production costs from multiple reports, across 17 countries and spanning 11 years. The production costs figure in the main text only displays countries for which we have at least 4 observations, to estimate a trend. Below, we show results from a regression analysis of all of the observations.

$$y_{it} = \alpha + \beta t + \gamma_i + \delta_v + \epsilon_{it}$$

where y_{it} is either real USD/kg prices in log or level terms for country i in year t, γ_i is an intercept for each country (the dropped country is Brazil), and δ_v is an intercept for the variety (the dropped variety is "unspecified").

	Dependent variable:	
	Log(USD/kg)	USD / kg
Trend (by year)	0.030*** (0.010)	0.061*** (0.023)
Burundi vs. Brazil	−1.512*** (0.263)	−2.175*** (0.612)
Cameron vs. Brazil	−1.755*** (0.270)	−1.762*** (0.627)
Colombia vs. Brazil	−0.043 (0.091)	−0.083 (0.213)
Costa Rica vs. Brazil	0.167 (0.119)	0.444 (0.276)
Ecuador vs. Brazil	0.431 (0.419)	1.680* (0.973)
El Salvador vs. Brazil	0.109 (0.114)	0.472* (0.266)
Ethiopia vs. Brazil	−2.125*** (0.217)	−2.401*** (0.503)
Guatemala vs. Brazil	−0.061 (0.377)	−0.077 (0.876)
Ivory Cost vs. Brazil	−1.391*** (0.270)	−1.634** (0.627)
Kenya vs. Brazil	−0.448* (0.264)	−0.155 (0.613)
Nicaragua vs. Brazil	−0.643*** (0.235)	−0.773 (0.547)
Peru vs. Brazil	−0.150 (0.377)	−0.341 (0.876)
Rwanda vs. Brazil	−1.485*** (0.370)	−2.180** (0.861)
Tanzania vs. Brazil	−1.381*** (0.173)	−1.790*** (0.401)
Uganda vs. Brazil	−1.091*** (0.270)	−1.486** (0.627)
Vietnam vs. Brazil	−0.881*** (0.270)	−1.325** (0.627)
Arabica vs. Unspec.	0.181 (0.192)	0.632 (0.447)
Robusta vs. Unspec.	−0.277 (0.199)	−0.079 (0.463)
Observations	180	180
R^2	0.727	0.501
Adjusted R^2	0.695	0.442
Residual Std. Error (df = 160)	0.368	0.855
F Statistic (df = 19; 160)	22.444***	8.457***
Note:		*p<0.1; **p<0.05; ***p<0.01

Costs Components – A. Direct Costs

A.1. Labor cost

There are two main categories of labor in the coffee production context. First, "harvest labor" refers to seasonal coffee pickers. Second, there is general labor or yearly labor needed to maintain the plantation. A third labor consists of administration staff, but this is usually accounted in cost estimates as administration rather than labor. It is important to mention that in small farms, these types of labor are overlapping with family labor, as family members would be performing many of the tasks. Overall labor costs differ significantly from one country to another. For instance, in El Salvador, labor makes up 6% of the overall cost, while it represents 12% of the total cost in Guatemala.[303]

A.2. Inputs/Supplies

Inputs and supplies are variable direct costs that include fertilizers, pesticides and fuel for machinery. These costs are injected over the course of the cropping seasons and depend on the expected yield. The costs fluctuate following the overall prices for agrochemical inputs such as fertilizer and pesticides, which are on their turn follow the changes in oil prices.[304]

Costs Components – B. Indirect Costs

B.1. Administration

Even though management are often neglected[305], the greatest part of the cost of coffee production is under administration according to Caravela Coffee study.[306] Administration costs includes administrative labor as well as supervisory expenses, legal costs, financial costs, and certification costs. In fact, 35% of costs in Colombia are administration costs and 37% in Ecuador.

B.2. Planting and Renovation

Planting and renovation costs are generated by the depreciation of the coffee plantation. Renovation of the plantation refers to removing old trees and replacing seedlings. This also covers adding new seedlings and shading material between current trees[307]. This is done because tree productivity decreases through time. In addition to this, some trees need to be replanted because of disease and pests. Other causes that might require renovation are the impact of climate change and poor agricultural practices. The establishment of the coffee plantation comprises the preparation of soil, costs of seedlings and the planting. This is a large part of the cost. However, this cost is divided over the lifetime of the coffee plantation. The lifespan varies significantly (between 8 and 20 years or more), depending on several factors including but not limited to the country and the management practices[308]. All of these activities require upfront investment[309]. However, because of the increasing costs, in particular labor costs, less budget is allocated to renovation. For instance, 1% of the production costs in Colombia is for renovation, while 5% is invested in renovation in El Salvador.

B.3. Infrastructure

Infrastructure refers to the type and capacity of facilities that the plantation contains. The process of coffee production includes several activities that need specific infrastructure. The cost structure thus depends on the type of facilities famers own, and the type of services provided in their context. For example, in Nicaragua farmers pay to dry their coffee[310]. Hence, Nicaragua has the highest infrastructure cost amongst Colombia, Ecuador, Peru, Guatemala and El Salvador[311].

Costs Components – C. Other Factors Impacting Cost Structure

C.1. Farm Level: Distinguishing average farms and/or different farm types

Some studies of coffee production costs classified farm types[312] and sizes for more accurate calculation of cost description and structure. One possible classification is dividing farms depending on both size and specialties. One classification of five farm types consists of Large coffee farms, Farms with off-farm activities, Coffee dependent farms, Diversified farms, and Banana/coffee farms.

The size and the type of the farm translate into an associated type of business model. This is true mostly because different business models entail different farming practices and decision-making processes, specific to each type[313]. This means that different types of farms have different technology adoption patterns[314]. Consequently, production costs (and in particular labor productivity and cost) depend substantially on different farm types.

To get a sense of the costs differences between business models, we note that Coffee specialists generated more than 75% of their revenue from coffee, Diversified coffee farmers generated 51% of their revenue from coffee, and Off-farm income farmers generated 15 % of their revenue from coffee[315].

C.2. National Legal Framework

This factor is related to national legal framework in coffee-producing countries. This would comprise both the active local associations in the coffee production and consumption ecosystem, as well as all formal regulations and coffee policies related to coffee production and commercialization. In Guatemala, for instance, there is both a Coffee Law, created in 1969[316], and a governmental entity called The National Coffee Association (ANACAFE), designated to be responsible for advising on coffee policies as well as providing research and informational services and farmers support (such as cupping, registration, statistics, and warehouses). The national legal framework appears to be a crucial component in promoting coffee production activities and shaping them, as it affects directly the cost production structure and the management practices of farmers.

C.3. Exchange rate

The payment to producers is usually made in dollars, which means that the fluctuation of the exchange rate has a significant impact on the total amount farmers get. For instance, if in Colombia, a dollar depreciates from 3,000 pesos down to 2,800 pesos, farmers would lose a considerable amount of their profit[317]. In general, the real impact of the fluctuations of exchange rates on the total amount farmers get is still unclear. This is mainly because of the effect of the fluctuation of the exchange rate on inputs such as fertilizer and pesticides. Undeniably, depreciation in global exchange rates against the dollar contributes to a significant cost risk[318].

C.4. Minimum Wage, Wage in Agriculture

Both the difference between rural and urban salaries and policies that enforce a minimum wage affect costs[319]. These increase labor costs[320]. This phenomenon is related to economic development and rural-urban migration. The cost of labor also has increased in many areas due to the higher cost of legal fees and insurance. Finally, the trend of workers out of agriculture, and the greater difficulty in finding workers for agriculture, reduces the labor supply and increases labor costs.

Costs Components – D. Other not-reflected Costs

This section gives an overview of the impact of the economic activities related to coffee production[321], which are not reflected in the price. This includes social costs and environmental costs.

D.1.Social

Social cost is one of the hidden costs in the supply chain of the coffee beans production. Some of the most important social price externalities are as follows:

D.1.1. Child Labor

Child labor is one of the dominant social costs. In African countries, a large percentage of the production chain workers (farmers mainly) are below the legal age of labor, making them undeclared workers.

D.1.2. Labor related (rural labor employed, forced labor, health and safety)

Other social cost externalities that have similar effects, while remain invisible in the price equation, are aspects related to social security (including health security, annual leaves, sickness, maternity and paternity leaves), and underpayment of the hired labor forces as well as unpaid overtime. The lack of or/and non-enforced labor rights in some of the most highly productive coffee beans countries is related to the reduced coffee costs. Other social aspects such as harassment (sexual or non-sexual), forced labor, and restrictions against unions, are not taken into account in the price calculations as well.

D.2. Environmental

Coffee cultivation, as any other crops, is being affected directly and indirectly by environmental factors. Over-fertilization and over-irrigation are common practices and are directly affecting the fertility of land. In addition, water pollution, land degradation, deforestation, temperature rise and green house effects have negative impact on coffee production and are indirectly affecting the costs and imposing externalized costs.

Some of the most important environmental related aspects are as follows:

D.2.1. Water use

Water use (especially in conventional farms) is considered the largest externalize environmental. For example, in Vietnam conventional farms use more than double the amount of water required per hectare. Unmonitored water use can lead to a decrease in the water tables in coffee areas, and the rise of temperatures and the prolonged droughts from climate change will impose additional costs.

D.2.2. Energy Use

Another important related factor is the energy consumption, directly connected to the water use as the electrical and diesel pumps are being used to pump groundwater for irrigation. The production of fertilizers is also an energy intensive process, exacerbated by the over-use of these chemicals.

D.2.3. Land Use

Land use is considered by many NGOs to be one of the most crucial environmental issues, especially when it is directly related to deforestation and drought. The quantification of land use impacts is challenging, but includes effects on local and global climate change, migration, and soil erosion.

4. Coffee Demand Model

Early work used both prices and incomes to explain demand, and found a price elasticity of demand of -0.26 and an income elasticity of demand of 0.23 in the US.[322] However, these estimates suffer from both challenges of co-integration and the endogeneity of prices.[323]

First, we solve these problems using an estimation approach the predicts differences rather than levels to address co-integration, and an instrumental variable approach using coffee production to instrument for prices to address endogeneity. We include the effect on demand both of prices and of country incomes, and allow prices and demand to evolve autoregressively. We show a normal econometric analysis first, and then improve upon this with a Bayesian approach. The Bayesian approach allows us to account for the variation of responses across countries, using a hierarchical Bayesian method, which causes country-specific data to be "partially pooled."[324] The partial pooling technique simultaneously estimates a pooled response and country-specific estimates of elasticities, allowing the country-specific estimates to be informed by the pooled response to the extent supported by the data.

The coffee demand model is estimated by the following pair of expressions:

$$log\ P_t = \alpha_1 + \tau_1 t\ + \beta_1\ log\ Q_{t-1} + \gamma_1\ log\ P_{t-1} + \epsilon_{1t}$$

$$\Delta\ log\ D_{it} = \alpha_{2j} + \tau_{2j} t + \beta_{2j} \Delta\ log\ \hat{P}_t + \gamma_{2j} \Delta\ log\ Y_{it} + \epsilon_{2it}$$

In the first expression, P_t is the international price in year t, and Q_{t-1} is the quantity produced in the previous growing season. This is the first stage of an instrumented variable regression, which uses production quantities to predict prices. Prices are influenced by production, so that when production increases, prices tend to decrease. However, prices also have a progression of their own, represented by an autoregressive term.

In the second expression, D_{it} is the amount demanded in country I and year t, and it is affected by the predicted price from the first stage, $\hat{P}_t$, and similarly has a strong autoregressive element. Demand also increases with income Y_{it}. The second expression is estimated in differences, which accounts for a different starting level in each country.

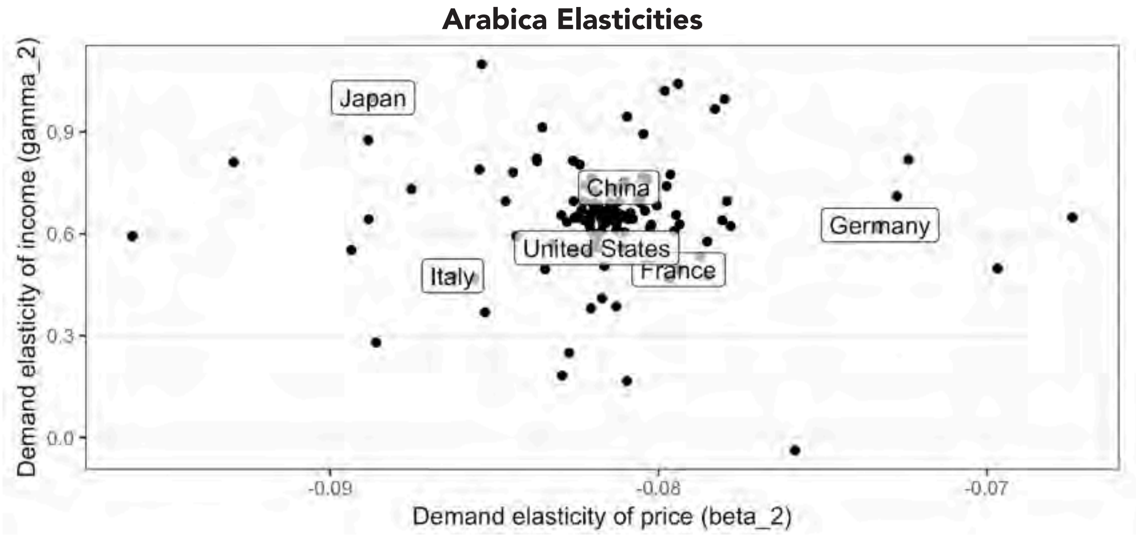
We perform these regressions in 6 different forms, with the results displayed in the table below. The basic instrumented variable regression is shown in columns IV1 (the first stage) and IV2 (the second stage). These show coefficients of the expected sign, but large amounts of uncertainty on the parameters of interest, the effect of quantity on prices and the effect of predicted prices on demand. When the true prices are used, rather than predicted prices, we see a stronger effect on Arabica demand, which is also statistically significant, with an elasticity of -0.075.

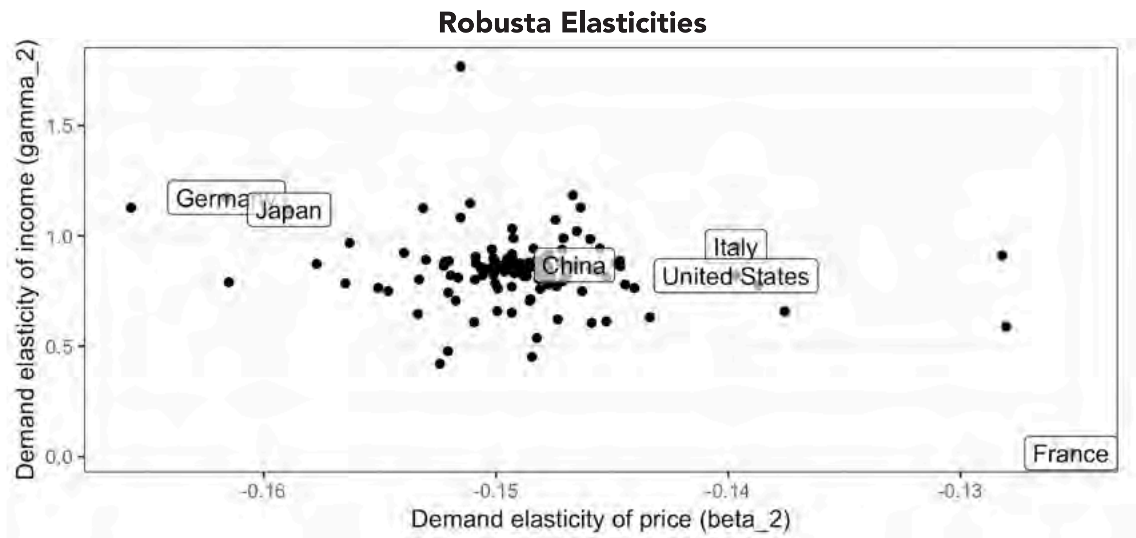
Finally, we run the instrumental variable approach as a computational Bayesian model. This allows us to place priors on the coefficient values, forcing the elasticities of production on price and of price on demand to both be negative. The first stage under these priors is shown in the Bayesian IV1 column. Entries with tildes after the number are limited by the prior to be positive or negative (which makes the standard econometric definition of statistical significance irrelevant). Next, we can run the first and second stages simultaneously. This allows the predictability of price in the second stage to influence the fit of the model in the first stage. This is shown in the Uniform column. Finally, we perform a hierarchical Bayesian regression, as described above, which has the same form, but where each region has its own values for the various parameters, partially pooled across regions as determined by the data. The hyperparameters of this model are shown in column Hierarchical, and this is the final form used in the report.

	Arabica					
	OLS			Bayesian		
Parameter	IV 1	IV 2	No IV	IV 1	Uniform	Hierarchical
α_1 (Constant)	7.131			9.914***	9.814***	14.556***
	(9.538)			(6.136)	(6.201)	(5.161)
τ_1 (Year)	0.00731			0.00982	0.00982	0.0142**
	(0.0105)			(0.00845)	(0.00784)	(0.00767)
β_1 (Production)	-0.469			-0.662~	-0.647~	-0.976~
	(0.660)			(0.424)	(0.424)	(0.362)
γ_1 (Autoreg.)	0.671***			0.674~	0.571~	0.590~
	(0.146)			(0.144)	(0.177)	(0.150)
α_2 (Const.)		0.0327	0.0309		0.0237*	0.00488
		(0.0208)	(0.0206)		(0.0151)	(0.00421)
τ_2 (Year)		0.00219**	0.00221**		0.000642	0.000186
		(0.00104)	(0.00102)		(0.000834)	(0.000237)
β_2 (Price)		-0.0459	-0.0747**		-0.0484~	-0.0816~
		(0.0525)	(0.0377)		(0.036)	(0.0301)
γ_2 (GDP p.c.)		0.666***	0.687***		0.592**	0.654***
		(0.206)	(0.205)		(0.272)	(0.122)
	Robusta					
	OLS			Bayesian		
Parameter	IV 1	IV 2	No IV	IV 1	Uniform	Hierarchical
α_1 (Constant)	21.938***			21.905***	19.492***	23.347***
	(8.032)			(8.219)	(7.667)	(5.498)
τ_1 (Year)	0.0581***			0.058***	0.0516***	0.0614***
	(0.0216)			(0.0223)	(0.0208)	(0.016)
β_1 (Production)	-1.603***			-1.600~	-1.423~	-1.704~
	(0.590)			(0.604)	(0.564)	(0.407)
γ_1 (Autoreg.)	0.642***			0.642~	0.648~	0.590~
	(0.118)			(0.125)	(0.120)	(0.112)
α_2 (Constant)		0.0706***	0.0654**		0.0336*	0.00991*
		(0.0269)	(0.027)		(0.0214)	(0.00658)
τ_2 (Year)		0.00091	0.000921		0.000232	-3.81e-05
		(0.00134)	(0.00132)		(0.00111)	(0.000321)
β_2 (Price)		-0.0938*	-0.0252		-0.119~	-0.149~
		(0.0532)	(0.0456)		(0.0663)	(0.0388)
γ_2 (GDP p.c.)		0.813***	0.908***		0.930***	0.842***
		(0.266)	(0.268)		(0.355)	(0.164)

The extent of variation across elasticities is estimated to be low. This is largely driven by the low precision of the elasticity coefficient in each country. These country-specific coefficients are shown below.

Country-specific elasticities of price and income. Each point represents a single country at the values of its elasticities. Some of the largest countries are labeled.



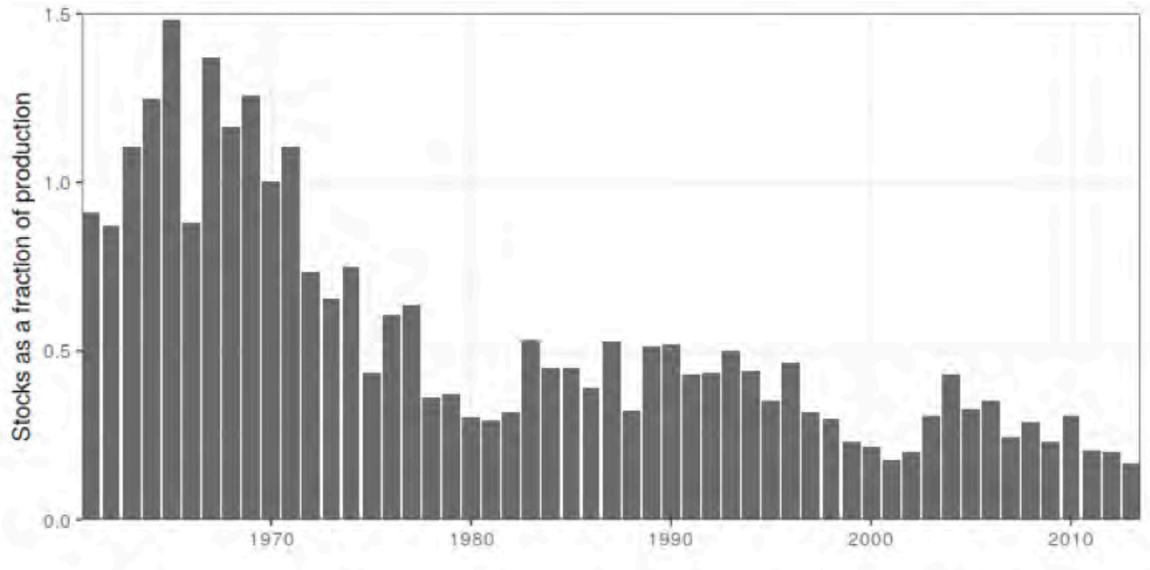


We then project these demands into the future, as income levels and population sizes change. Real GDP growth rates by country were taken from the IMF,[325] available through 2024. Growth rates after 2024 are held constant at the average growth rate from 2020 – 2024. Population evolves according to the UN Population Division medium projection.

In each period in the model projection, we update demand curves for each country, and then solve for the equilibrium price. If the equilibrium price for Robusta beans is greater than the equilibrium price for Arabica beans (which can happen in extreme scenarios, but does not occur in the main scenarios we present), we allow Arabica beans to be sold on the Robusta market to equalize the prices.

5. Stock Model

Stock levels averaged 2 million tons (about 25% of production) between 2004 - 2013 (see below).



Stocks show a cyclical style, similar to coffee production, but offset. This reflects strategic behavior, to build up stocks in periods where prices are low, and sell them on the expectation that the next year will have a better price.

Since green coffee beans can be stored for up to a year without losing significant quality, we take a yearly timestep for the model, assuming that timing within each year of the collection and release of stocks does not matter for equilibrium prices. The model fit is shown the table below. The largest component is an autoregressive term, which also reflects stock managers' expectations of future prices.

	Dependent variable:
	Stocks
Autoregressive term	0.801*** (0.154)
International price ($/kg)	−2.526* (1.413)
Constant	12,762.300** (5,531.720)
Observations	24
R^2	0.562
Adjusted R^2	0.520
Residual Std. Error	5,892.445 (df = 21)
F Statistic	13.470*** (df = 2; 21)
Note:	*p<0.1; **p<0.05; ***p<0.01

Under prediction, we use this estimate to build a consistent handling stocks in response to prices, as follows:

$$S_{t+1} = \frac{1}{2}S_t + \alpha + (\beta - \frac{1}{2})\,S_0 + \gamma\frac{P_{arabica} + P_{robusta}}{2}$$

Where α=12762.3, β=0.801, and γ=-2.526. In this expression, we cap the direct autoregression at 50%, to represent the show time period that green beans can be stored. The remainder of the autoregressive effect is used to center the stocks around their most recent levels, of 1 million MT.

Changes in the stocks from year to year are added to or subtracted from the supply available for consumption, with 2/3 of the change assumed to be Arabica, and 1/3 assumed to be Robusta. The remainder of the supply is consumed, according to the country-level proportions from the demand model.

6. Market Equilibrium

To combine the supply and demand models to construct equilibrium international prices, we start by taking production quantity as given. Since the farming decisions behind production have already been made, the equilibrium within each year cannot affect production.

Since this dynamic changes the prices, when we determine a joint equilibrium between demand and stocks. To do this, we find a fixed point between two relationships. On one hand, the price is determined by the demand curve, inverted based on total production plus any changes in the stock released to the market. On the other hand, the price level should predict those same changes in stocks released. We determine a fixed point between these two relationships.

This equilibrium price is then fed into the production model to influence the next year's levels of production. Although decisions around new planting can take years to influence the price, price changes can have immediate effects on harvest levels and on cultivation reductions.

Endnotes

1 Enveritas, which has undertaken one of the most recent and rigorous estimates of the number of coffee farmers globally, estimates that there are approximately 12.5 million coffee farmers. Enveritas, "How many coffee farmers are there? Global coffee farm study," (2018). Assuming 5 members per coffee farming household, coffee farming would thus sustain the livelihoods of approximately 62.5 million people. Previous studies have estimated both a higher number of coffee farmers (25 million) and of livelihoods dependent on coffee (100-125 million). See e.g., Fairtrade Foundation, "Coffee Farmers," available at: http://www.fairtrade.org.uk/Farmers-and-Workers/Coffee (last visited Sept. 5, 2019); Sjoerd Panhuysen and Joost Pierrot, "Coffee Barometer 2018," (2018), available at: https://www.hivos.org/assets/2018/06/Coffee-Barometer-2018.pdf (last visited September 16, 2019).

2 Sjoerd Panhuysen and Joost Pierrot, "Coffee Barometer 2018," (2018), supra note 1.

3 Ibid., p. 19 and Section 3.

4 Luis Samper, Daniel Giovannucci, and Luciana Marques Vieira, "The Powerful Role of Intangibles in the Coffee Value Chain," Economic Research Working Paper No. 39, (2017), p. 7.; International Coffee Organization, "Assessing the economic sustainability of coffee growing: International Coffee Council 117th Session, held at London, United Kingdom, from 19 to 23 September 2016," (September 15, 2016), p 22, available at: http://www.ico.org/documents/cy2015-16/icc-117-6e-economic-sustainability.pdf (last visited July 2, 2019) (finding that, aside from Brazil, the other 3 countries studied had low average short-term profitability and decreasing profitability overall, and noting that even when more productive, farmers "may still incur losses in years of low prices."); The Global Coffee Platform, available at: https://www.globalcoffeeplatform.org/collective-action-networks/economic-viability-of-farming#introduction (last visited July 1, 2019) ("However, coffee production at farm level is not economically viable for many smallholder farmers ….").

5 "The Powerful Role of Intangibles in the Coffee Value Chain," (2017), supra note 4, p. 7. There often is not enough market demand to compensate for farmers' costs of incorporating more sustainable practices, and a staggering amount of the coffee produced under sustainability standards is not sold as such; Sjoerd Panhuysen and Joost Pierrot, Coffee Barometer 2018, supra note 1, p 19. Like coffee itself, there is currently more supply than demand for certified coffee.

6 International Coffee Organization, "Survey on the impact of low coffee prices on exporting countries: International Coffee Council 124th Session, held at Nairobi, Kenya, from 25 to 29 March 2019," (March 4, 2019), Figure 29, p. 17, available at: http://www.ico.org/documents/cy2018-19/Restricted/icc-124-4e-impact-low-prices.pdf (last visited July 2, 2019).

7 Ibid.

8 Verité, "Project Coffee," available at: https://www.verite.org/project/coffee-3/ (last visited July 1, 2019); see also Business & Human Rights Resource Centre, available at: https://www.business-humanrights.org/en/brazil-conectas-union-adere-mg-file-oecd-complaint-accusing-6-companies-of-forced-labour-in-their-supply-chains (last visited July 1, 2019); Lopes, Marina, "The hidden suffering behind the Brazilian coffee that jump-starts American mornings," The Washington Post, August 31, 2018, available at: https://www.washingtonpost.com/world/the_americas/the-hidden-suffering-behind-the-brazilian-coffee-that-jump-starts-american-mornings/2018/08/30/e5e5a59a-8ad4-11e8-9d59-dccc2c0cabcf_story.html (last visited July 1, 2019).

9 Camargos, Daniel, "Slave labor found at second Starbucks-certified Brazilian coffee farm," Mongabay, May 3, 2019, available at: https://news.mongabay.com/2019/05/slave-labor-found-at-second-starbucks-certified-brazilian-coffee-farm/ (last visited July 1, 2019).

10 Verité, "Project Coffee," supra note 8.

11 See e.g., Enveritas, "Coffee harvest labor analysis in Honduras," June 2019 Preliminary Version (comparing the amount of labor required to pick the entire Honduran coffee harvest to the available adult workers in rural areas, and finding that the ratio – 1 in 3 rural workers needing to harvest coffee for a full month – indicates widespread use of child labor); Verité, "Project Coffee: Coffee: Summary of Key Trafficking in Persons Issues in Coffee Production," supra note 8 (noting that coffee is produced with forced child labor in Cote d'Ivoire); Heather Randell and Clark Gray, "Climate variability and educational attainment: Evidence

from rural Ethiopia," Global environmental change: human and policy dimensions vol. 41 (2016): 111. doi:10.1016/j.gloenvcha.2016.09.006 (finding that child labor goes up in drought years in Ethiopia).

12 United States Department of Labor, available at: http://bit.ly/2G8H8d8 (last accessed July 9, 2019).

13 See e.g. Verité, "Project Coffee," supra note 8 (detailing various practices that coffee workers may be subjected to, and noting that "[m]inimum wage violations are common, even on farms producing gourmet coffee"). While there is mixed evidence about whether certification helps coffee workers, there are clearly still gaps in worker income and wellbeing on certified farms. See e.g. Thomas Dietz, Janina Grabs, and Andrea Estrella Chong, "Mainstreamed voluntary sustainability standards and their effectiveness: Evidence from the Honduran coffee sector: Effectiveness of mainstreamed VSS," Regulation & Governance, (2019): 10.1111/rego.12239 (finding that, in Honduras in 2016, farmers paid less than the agricultural minimum wage per day of US $8.30, with average wages varying by certification class, from $6.46 for Rainforest Alliance-certified farms to $5.07 for Fair Trade-certified farms); Christopher Cramer, Deborah Johnston, Bernd Mueller, Carlos Oya, and John Sender, "Fairtrade and Labour Markets in Ethiopia and Uganda," The Journal of Development Studies, (2017): 53:6, 848, DOI: 10.1080/00220388.2016.1208175 (finding that wage workers at sites with Fair Trade producer support organizations make less money and have poorer working conditions than wage workers at non-certified farm sites, both large and small).

14 "World Coffee Producers Forum declares need for action on coffee price," World Coffee Report, March 27, 2019, available at: http://gcrmag.com/news/article/world-coffee-producers-forum-declares-need-for-action-on-coffee-price (last visited July 2, 2019).

15 Global Coffee Platform: Time for action!, available at: https://www.globalcoffeeplatform.org/latest/2019/gcp-calls-on-all-its-members-to-collectivelly-stop-the-price-crisis#newsheader (last visited July 2, 2019).

16 "SCA Launches New Initiative to Address the Coffee Price Crisis and Appoints New Executive Director," Specialty Coffee Association, December 13, 2018, available at: https://scanews.coffee/news/sca-launches-new-initiative-to-address-the-coffee-price-crisis-and-appoints-new-executive-director/ (last visited July 2, 2019).

17 Kirk Semple, "Central American Farmers Head to the U.S., Fleeing Climate Change," The New York Times, April 13, 2019, available at: https://www.nytimes.com/2019/04/13/world/americas/coffee-climate-change-migration.html (last visited July 2, 2019).

18 Mitra Taj, "Coffee farmers in Peru abandon crops to grow coca: group," Reuters, February 25, 2019, available at: https://www.reuters.com/article/us-peru-drugs/coffee-farmers-in-peru-abandon-crops-to-grow-coca-group-idUSKCN1QE2ON (last visited July 2, 2019); see also Emiko Terazono, Jude Webber, and Andres Schipani, "The abandoned farms behind the global coffee craze," Financial Times, May 20, 2019, available at: https://www.ft.com/content/5009be96-7569-11e9-be7d-6d846537acab (last visited July 2, 2019).

19 United Nations Sustainable Development Summit 2015, available at: https://sustainabledevelopment.un.org/post2015/summit (last visited July 2, 2019).

20 Interview with coffee association representative, March 4 (2019); see also International Coffee Organization, "Assessing the economic sustainability of coffee growing: International Coffee Council 117th Session, held at London, United Kingdom, from 19 to 23 September 2016," supra note 4, p 2 (noting "there is a widespread concern in the coffee sector that a prolonged phase of low coffee prices could negatively affect the supply of high quality coffee beans").

21 Julia Wilson, "Five Reasons to Prioritize Sustainability in Your Brand Playbook," Nielsen, (June 12, 2018), available at: https://www.nielsen.com/sa/en/insights/article/2018/five-reasons-to-prioritize-sustainability-in-your-brand-playbook/ (last visited August 12, 2019).

22 Aaron Maasho and Nigel Hunt, "Coffee price slump leaves farmers earning less than a cent a cup," Reuters, January 14, 2019, available at: https://www.reuters.com/article/coffee-farmers/coffee-price-slump-leaves-farmers-earning-less-than-a-cent-a-cup-idUSL8N1YJ4D2 (last visited July 2, 2019); similar comment in Emiko Terazono, Jude Webber, and Andres Schipani, "The abandoned farms behind the global coffee craze," supra note 18.

23 International Coffee Organization, "Achieving the Sustainable Development Goals in the Coffee Sector: Background Paper – ICO/ECF Symposium, held at Brussels, on 6 June 2019," (2019); International Coffee Organization, "Assessing the economic sustainability of coffee growing: International Coffee Council 117th

Session, held at London, United Kingdom, from 19 to 23 September 2016," supra note 4 ("Hence, joint action is needed by all stakeholders in the sector, including farmers, traders, roasters, consumers, governments, academia and research institutions, as well as development partners, to identify solutions that help to alleviate the short-term impact of low prices and to put the coffee sector on a positive development and sustainability trajectory.").

24 The export quotas covered 98 percent of the world export volume to importing member countries. Quotas for each exporting member country were based on past export volumes. Producers that surpassed their export quotas under the ICA could sell excess coffee supply to the non-quota market at a discount. These lower prices are not captured by the ICO composite price (Source: Takamasa Akiyama and Panayotis N. Varangis, "The Impact of the International Coffee Agreement on Producing Countries," The World Bank Economic Review, 4(2), p. 159). This means that, depending on the export quota and actual amount produced within a country, the average price for a country's coffee may have been significantly less (if, for example, a significant percentage of the coffee produced was sold to the non-quota market at a discount). In addition, farmers generally failed to receive most of the benefit of higher prices, which was lost in export taxes or to third parties via rent seeking (source: Bryan Lewin, Daniele Giovannucci, and Panayotis Varangis, "Coffee Markets: New Paradigms in Global Demand and Supply," Agriculture and Rural Development Working Paper, March 2004, p. 27).

25 Following the abandonment of the quota system, world coffee prices fell by more than 40% (source: Takamasa Akiyama and Panayotis N. Varangis, "The Impact of the International Coffee Agreement on Producing Countries," supra note 24, p.159).

26 International Coffee Organization, "Country Coffee Profile: Vietnam: International Coffee Council 124th Session, held at Nairobi, Kenya, from 25 to 29 March 2019," (March 4, 2019) supra note 6.

27 Global Coffee Platform, "A quick scan on improving the economic viability of coffee farming – Vietnam," available at: https://www.globalcoffeeplatform.org/resources/a-quick-scan-on-improving-the-economic-viability-of-coffee-farming (last visited July 3, 2019).

28 Ngoc Hung, "Nestle Vietnam supports coffee replanting" The Saigon Times, March 13, 2013, available at: https://english.thesaigontimes.vn/28211/Nestle-Vietnam-supports-coffee-replanting.html (last visited September 24, 2019).

29 Ibid.

30 Floréncio de Almeida, Luciana and Decio Zylbersztajn, "Key success factors in the Brazilian coffee agrichain: Present and future challenges," 8(1) International Journal on Food System Dynamics 45-53 (2017), pp. 50-51.

31 Ibid.

32 Luis Samper, Daniel Giovannucci, and Luciana Marques Vieira, "The Powerful Role of Intangibles in the Coffee Value Chain," supra note 4.

33 International Coffee Organization, "Assessing the economic sustainability of coffee growing: International Coffee Council 117th Session, held at London, United Kingdom, from 19 to 23 September 2016," supra note 4 Specialty Coffee Association, "Coffee Production Costs and farm Profitability: Strategic Literature Review," (October 2017), available at: https://static1.squarespace.com/static/584f6bbef5e23149e5522201/t/5c2cd83970a6adae0b4747bf/1546442816347/Coffee (last visited August 12, 2019); Caravela Coffee, "A Study on Costs of Production in Latin America," (July 2019) available at: https://caravela.coffee/whitepaper-contact-a-study-on-costs-of-production-in-latin-america/ (last visited August 12, 2019).,

34 Caravela Coffee, "A Study on Costs of Production in Latin America," July 2019, supra note 45.

35 International Coffee Organization, "Assessing the economic sustainability of coffee growing: International Coffee Council 117th Session, held at London, United Kingdom, from 19 to 23 September 2016," supra note 4.

36 International Coffee Organization, "Achieving the Sustainable Development Goals in the Coffee Sector: Background Paper – ICO/ECF Symposium, held at Brussels on June 6 2019," supra note 23.

37 Julie Wernau and Robbie Whekan, "Low Coffee-bean prices brew trouble for farmers," Wall Street Journal, December 19, 2018, available at: https://www.wsj.com/articles/low-coffee-bean-prices-brew-trouble-for-farmers-11545228000 (last visited July 2, 2019).

38 International Coffee Organization, "Achieving the Sustainable Development Goals in the Coffee Sector: Background Paper – ICO/ECF Symposium, held at Brussels on June 6 2019," supra note 23.

39 Luis Samper, Daniel Giovannucci, and Luciana Marques Vieira, “The Powerful Role of Intangibles in the Coffee Value Chain,” supra note 4, p. 6.
40 Ibid.
41 Ibid.
42 Ratio of operating income to net sales
43 Macrotrends Starbucks Profit Margin 2006-2019, available at: https://www.macrotrends.net/stocks/charts/SBUX/starbucks/profit-margins (last visited July 5, 2019).
44 Macrotrends Keurig Dr. Pepper Profit Margin 2008-2019, available at: https://www.macrotrends.net/stocks/charts/KDP/keurig-dr-pepper/profit-margins (last visited July 5, 2019).
45 Devra Gartenstein, “The Average Profits for a Small Café,” Houston Chronicle, January 31, 2019.
46 Mordor Intelligence, “Coffee Market – Growth, Trends and Forecasts (2019-2024),” (2019).
47 CB Insights, “Caffeine High: Coffee Funding Skyrockets in 2018,” (August 13, 2018), available at: https://www.cbinsights.com/research/coffee-funding-trends/ (last visited July 5, 2019).
48 Thomas Dietz, Janina Grabs, and Andrea Estrella Chong, “Mainstreamed voluntary sustainability standards and their effectiveness: evidence from the Honduran coffee sector” (2019) supra note 13.
49 Kate Taylor, “Nestlé and Blue Bottle couldn’t be more different — but here’s why the companies could be the perfect match,” Business Insider, (September 14, 2017), available at: https://www.businessinsider.com/nestle-blue-bottle-500-million-acquisition-partnership-2017-9 (last visited August 12, 2019).
50 The literature recognizes how Starbucks has mastered the value of branding over time, which has translated into very high customer loyalty (among the highest in the hospitality business); see e.g., Sara J. Ghafoorzadeh, “Customers’ Loyalty & Brand Experience,” Helsinki Metropolia University of Applied Sciences (November 5, 2013) available at: https://core.ac.uk/download/pdf/38099152.pdf (last visited August 12, 2019); Kavita Kumar, “An Analysis on Brand Loyalty: A Case Study on Starbucks,” California State Polytechnic University, (2016), available at: http://dspace.calstate.edu/bitstream/handle/10211.3/173524/KumarKavita_Project2016.pdf?sequence=3 (last visited August 12, 2019).
51 Katie Johnston Chase, “Starbucks deal solidifies Green Mountain’s market lead,” boston.com, (March 11, 2011), available at: http://archive.boston.com/ae/food/restaurants/articles/2011/03/11/starbucks_teams_with_maker_of_keurig_coffee_brewer/?page=1 (last visited August 12, 2019).
52 Rachel Sanderson, “Nestlé eyes Europe foray for Blue Bottle Coffee,” (September 10, 2018), available at: https://www.ft.com/content/e34c0412-b41b-11e8-bbc3-ccd7de085ffe (last visited September 16, 2019).
53 BBC News, “Nestle pays Starbucks $7.1bn to sell its coffee,” (May 7m 2018), available at: https://www.bbc.com/news/business-44027773 (last visited August 15, 2019).
54 “Nestle to pay $7.15 billion to Starbucks to jump-start coffee business,” CNBC, (May 7, 2018), available at: https://www.cnbc.com/2018/05/07/nestle-to-pay-7-point-15-billion-to-starbucks-in-coffee-tie-up.html (last visited August 12, 2019).
55 “Why A Starbucks-Kraft Feud Will Be Costly For Both Companies,” Business Insider, (December 14, 2010), available at: https://www.businessinsider.com/starbucks-kraft-2010-12 (last visited August 12, 2019).
56 Similarly JAB Holding signed a licensing deal with Illy to produce and distribute Illy coffee products internationally, outside of Italy (source: Lana Guggenheim, “Italian Coffee Producers Hold Global Market Share Despite Rising Competition,” South EU Summit, (March 25, 2019), available at: https://www.southeusummit.com/europe/italy/italian-coffee-producers-hold-global-market-share-despite-rising-competition/ (last visited August 12, 2019).
57 Thomas Dietz, Janina Grabs, and Andrea Estrella Chong, “Mainstreamed voluntary sustainability standards and their effectiveness: evidence from the Honduran coffee sector” (2019) supra note 13.
58 Max Nisen, “America loves K-cups, but instant coffee rules the world,” Quartz, (May 9, 2014), available at: https://qz.com/207354/america-loves-k-cups-but-instant-coffee-rules-the-world/ (last visited August 12, 2019).
59 In the US, as of today, Keurig holds 30% of market share among single cup coffee vendors (source: Jan Conway, “Keurig Green Mountain – Statistics & Facts,” Statistica (March 19, 2018), available at: https://www.statista.com/topics/2235/keurig-green-moutain/ (last visited August 12, 2019); See also Patterson Belknap Webb and Tyler LLP, “In Long-Awaited Opinion, Court Rules That Keurig Must Face Antitrust Suits

by Competitors and Customers," JD Supra, (May 16, 2019), available at: https://www.jdsupra.com/legalnews/in-long-awaited-opinion-court-rules-47575/ (last visited August 12, 2019). (describing ongoing litigation alleging monopoly power and anticompetitive behavior).

60 In Western Europe, these Nestle brands held 40% of the market as of 2016, Corinne Gretler, "Nestlé's coffee business is competing with itself," Moneyweb, (June 29, 2016), available at: https://www.moneyweb.co.za/news-fast-news/nestles-coffee-business-competing/ (last visited August 12, 2019).

61 Thomas Dietz, Janina Grabs, and Andrea Estrella Chong, "Mainstreamed voluntary sustainability standards and their effectiveness: evidence from the Honduran coffee sector" (2019) supra note 13.

62 In the US, as of today, Starbucks' market share in the coffee chain industry is about 40% (source: S. Lock, "Starbucks – Statistics & Facts," Statistica (August 27, 2018), available at: https://www.statista.com/topics/1246/starbucks/ (last visited August 12, 2019).

63 BASIC, "Coffee: The Hidden Crisis Behind the Success: Study on Sustainability Within the Coffee Industry Research Report," available at: https://reilukauppa.fi/wp-content/uploads/2019/05/Coffee-The-Hidden-Crisis-Behind-the-Success.pdf (last visited July 8, 2019).

64 Starbucks Reserve, available at: https://www.starbucksreserve.com/en-us/visit (last visited July 5, 2019).

65 BASIC, "Coffee: The Hidden Crisis Behind the Success," supra note 78.

66 Luis Samper, Daniel Giovannucci, and Luciana Marques Vieira, "The Powerful Role of Intangibles in the Coffee Value Chain," supra note 4.

67 BASIC, "Coffee: The Hidden Crisis Behind the Success," supra note 78.

68 International Coffee Organization, "Survey on the impact of low coffee prices on exporting countries: International Coffee Council 124th Session, held at Nairobi, Kenya, from 25 to 29 March 2019," supra note 6, p. 16.

69 Ibid.

70 Sara D. Elder, Jane Lister, and Peter Dauvergne. "Big Retail and Sustainable Coffee: A New Development Studies Research Agenda," Progress in Development Studies 14, no. 1 (January 2014): 77–90, available at: https://doi.org/10.1177/1464993413504354 (last visited August 12, 2019); Katerina Haskova, "Starbucks Marketing Analysis," De Gruyter Open, (January 2005), available at: https://www.degruyter.com/downloadpdf/j/cris.2015.2015.issue-1/cris-2015-0002/cris-2015-0002.pdf (last visited August 12, 2019); On Starbuck's marketing strategy and on the sales boon by integrating sustainability in products, see here: "What's Sustainability Got To Do With It?" The Nielsen Company, (2018), available at: https://www.nielsen.com/wp-content/uploads/sites/3/2019/04/whats-sustainability-got-to-do-with-it.pdf (last visited August 12, 2019).

71 Julia Wilson, "Five Reasons to Prioritize Sustainability in Your Brand Playbook," Nielsen, June 12, 2018, supra note 21; Daniel Fisher, "The Millennial Consumer: A Driving Force For Corporate Sustainability," Ecosphere (January 22, 2018), available at: https://ecosphere.plus/blog/millennial-consumer-driving-force-corporate-sustainability/ (last visited August 12, 2019); "Millennials want true commitment to SDGs. Companies can start by listening," Citibeats, (May 2, 2018), available at: https://citibeats.net/millennials-sdgs-csr/ (last visited August 12, 2019).

72 World Bank, Commodity Markets, available at: http://www.worldbank.org/en/research/commodity-markets (last visited July 3, 2019).

73 Federal Reserve Bank of St. Louis Exchange Rates, available at: https://fred.stlouisfed.org/ (last visited August 15, 2019).

74 Ibid.

75 FAO Data Portal, available at: http://www.fao.org/data/en/.

76 International Trade Center, Coffee's Export Guide – Third Edition, December 2012, available at: http://www.intracen.org/The-Coffee-Exporters-Guide---Third-Edition/

77 International Coffee Organization, "Futures markets: the role of non-commercial traders," (March 2019).

78 Ibid.

79 Stefan Ederer, Christine Heumesser and Cornelia Staritz, "Financialization and commodity prices – an empirical analysis for coffee, cotton, wheat and oil," International Review of Applied Economics, (2016), 30:4, 462-487

80 See: Jesus Crespo Cuaresma, Jaroslava Hlouskova, and Michael Obersteiner, “Fundamentals, speculation or macroeconomic conditions? Modelling and forecasting Arabica coffee prices,” European Review of Agricultural Economics, Volume 45, Issue 4, September 2018, available at: https://academic.oup.com/erae/article-abstract/45/4/583/4985577; International Coffee Organization, “Futures markets: the role of non-commercial traders,” (March 2019), available at: http://www.ico.org/documents/cy2018-19/Restricted/icc-124-5e-futures-markets.pdf (last visited September 17, 2019); Bryce Cooke and Miguel Robles, “Recent Food Prices Movements. A Time Series Analysis,” IFPRI Discussion Paper No. 00942, (2009); Abby Kim, “Does futures speculation destabilize commodity markets?” Journal of Futures Markets 35.8 (2015): 696-714.

81 Bernardina Algieri and Arturo Leccadito, “Price volatility and speculative activities in futures commodity markets: A combination of combinations of p-values test,” Journal of Commodity Markets, March 2019, available at: https://www.sciencedirect.com/science/article/pii/S2405851317300156.

82 Miguel Robles, Maximo Torero, and Joachim Von Braun, “When speculation matters,” Washington, DC: International Food Policy Research Institute (IFPRI), (2009), available at: https://www.cftc.gov/sites/default/files/idc/groups/public/@swaps/documents/file/plstudy_40_ifpri.pdf

83 International Coffee Organization, “Futures markets: the role of non-commercial traders,” (March 2019).

84 Ibid.

85 International Coffee Organization, “Assessing the economic sustainability of coffee growing: International Coffee Council 117th Session, held at London, United Kingdom, from 19 to 23 September 2016,” supra note 4; Specialty Coffee Association, “Coffee Production Costs and farm Profitability: Strategic Literature Review,” (October 2017), available at: https://static1.squarespace.com/static/584f6bbef5e23149e5522201/t/5c2cd83970a6adae0b4747bf/1546442816347/Coffee (last visited August 12, 2019); Caravela Coffee, “A Study on Costs of Production in Latin America,” (July 2019) available at: https://caravela.coffee/whitepaper-contact-a-study-on-costs-of-production-in-latin-america/ (last visited August 12, 2019).

86 Adapted from Maram Foundation for Relief and Development, Organization Profile, 2015-2019, available at: http://maramfoundation.org (last visited August 12, 2019).

87 Luis Samper, Daniel Giovannucci, and Luciana Marques Vieira, “The Powerful Role of Intangibles in the Coffee Value Chain,” supra note 4, p. 6.

88 International Coffee Organization, “Survey on the impact of low coffee prices on exporting countries: Int. Coffee Council 124th Session, held at Nairobi, Kenya, from 25 to 29 March 2019,” supra note 6, p. 16.

89 BASIC, “Coffee: The Hidden Crisis Behind the Success,” supra note 78.

90 Or otherwise sell to non-participating countries at a discount; see supra note 24.

91 See Box 7 for additional reasons.

92 While this discussion simplifies the issues for analytical clarity, important nuances—including distinguishing Robusta coffee and Arabica coffee, as well as acknowledging ranges of productivity within ROW—are factored into our model, the findings of which are provided in the next section.

93 Instituto Brasileiro de Geografia e Estatística. Tabela 1613 – Área destinada à colheita, área colhida, quantidade produzida, rendimento médio e valor da produção das lavouras permanents. Accessed Oct. 25, 2018.

94 Different datasets give different values for current global planting. Food and Agriculture Organization (FAOSTAT), http://www.fao.org/faostat/en/#data/QC (1.8 million ha in 2017, the latest year available); USDA-NASS, QuickStats: Agricultural Statistics Database (2019) (1.9 million ha).

95 Federal Republic of Brazil. Intended Nationally Determined Contribution towards Achieving the Objective of the United Nations Framework Convention on Climate Change.

96 The mechanical harvester developed by Cenicafé is a machine that vibrates at a certain frequency and that can be placed against a coffee tree branch to help take down coffee cherries. This machine does not replace hand-picking in mountainous areas, but helps to reduce labor requirements (with estimates that it could cut harvest time by 30%). A video demonstration is available at: https://www.youtube.com/watch?v=uzUnDDdZS1E (minute 22:58).

97 P. Imbach, et al., “Coupling of pollination services and coffee suitability under climate change,” Proceedings of the national academy of sciences, 114(39), 10438-10442 (2017), available at: https://www.ncbi.nlm.nih.gov/pubmed/28893985 (last visited September 17, 2019).

98 M Alves, et al., “Ecological zoning of soybean rust, coffee rust and banana black sigatoka based on Brazilian climate changes,” Procedia Environmental Sciences, 6:35–49 (2011).
99 Juliana Jaramillo, Eric Muchugu, Fernando E. Vega, Aaron Davis, Christian Borgemeister, and Adenirin Chabi-Olaye, “Some Like It Hot: The Influence and Implications of Climate Change on Coffee Berry Borer (Hypothenemus Hampei) and Coffee Production in East Africa.” PLoS ONE, (2011), available at: https://doi.org/10.1371/journal.pone.0024528; D. Kutywayo et al., “The impact of climate change on the potential distribution of agricultural pests: the case of the coffee white stem borer (monochamus leuconotus p.) in Zimbabwe,” PloS ONE, (2013) 8(8):e73432.
100 A.J. Challinor, Watson, J., Lobell, D. B., Howden, S. M., Smith, D. R., and Chhetri, N, “A meta-analysis of crop yield under climate change and adaptation,” Nature Climate Change, (2014), 4(4), 287; T.J. Troy, Kipgen, C., & Pal, I., “The impact of climate extremes and irrigation on US crop yields,” *Environmental Research Letters*, (2015), *10*(5), 054013.
101 P. Läderach, Ramirez–Villegas, J., Navarro-Racines, C., Zelaya, C., Martinez–Valle, A., and Jarvis, A, “Climate change adaptation of coffee production in space and time,” Climatic change, (2017), 141(1), 47-62.
102 R Burgess, Deschenes, O., Donaldson, D., and Greenstone, M., “The unequal effects of weather and climate change: Evidence from mortality in India,” Cambridge, United States: Massachusetts Institute of Technology, Department of Economics. Manuscript, (2017). M. Gonzalez-Quiroz, et al., “Decline in kidney function among apparently healthy young adults at risk of Mesoamerican nephropathy,” Journal of the American Society of Nephrology, (2018), 29(8), 2200-2212.
103 K. Jessoe, Manning, D. T., and Taylor, J. E., “Climate change and labor markets in rural Mexico: Evidence from annual fluctuations in weather,” (2018) (No. 329-2016-13136, pp. 3-33).
104 M. Schmitt-Harsh, “Landscape change in Guatemala: Driving forces of forest and coffee agroforest expansion and contraction from 1990 to 2010,” Applied Geography, (2013), 40, 40-50; T Killeen, and Harper, G., “Coffee in the 21st Century: will climate change and increased demand lead to new deforestation?” *Conservation International* (2016).
105 Here we consider the coffee belt between the Tropics of Capricorn and Cancer (23.4° S to 23.4° N), but we also show results for an expanded range below.
106 Rising et al. (2016). The impacts of climate change on coffee: trouble brewing, available at http://eicoffee.net/files/report/public.pdf. This text reflects data from R. J. Hijmans, Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A., “The WorldClim interpolated global terrestrial climate surfaces.” (2004), Version 1.3.
107 GISTEMP, “GISS Surface Temperature Analysis (GISTEMP).”
108 Christian Bunn, Mark Lundy, Peter Läderach, Evan Girvetz, and Fabio Castro, “Climate Smart coffee in Honduras,” International Center for Tropical Agriculture and United States Agency for International Development, (2018), available at: https://cgspace.cgiar.org/handle/10568/97530 (last visited August 13, 2019).
109 IPCC, “Climate Change 2014 – Impacts, Adaptation and Vulnerability: Global and Sectoral Aspects,” Cambridge University Press, (2014).
110 Wolfram Schlenker and Michael J. Roberts, “Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change,” Proceedings of the National Academy of Sciences, (2009), available at: https://doi.org/10.1073/pnas.0906865106; A. C.W. Craparo, Van Asten, P. J., Läderach, P., Jassogne, L. T., and Grab, S. W., “Coffee Arabica yields decline in Tanzania due to climate change: Global implications,” Agricultural and Forest Meteorology, (2015), 207, 1-10.
111 Ethan E. Butler, and Peter Huybers, “Adaptation of US Maize to Temperature Variations,” Nature Climate Change, (2013), available at: https://doi.org/10.1038/nclimate1585.
112 Nerlove, Marc, and William Addison. 1958. “Statistical Estimation of Long-Run Elasticities of Supply and Demand.” Journal of Farm Economics. https://doi.org/10.2307/1234772.
113 Ibid.
114 P. U. Kutty, “Demand for coffee imports: an econometric analysis,” Foreign Trade Review, (2000), 35(2-3), 91-100;ICO, “Price-elasticity of demand and coffee consumption in importing countries,” (2014), available at: http://www.ico.org/documents/eb3871e.pdf.
115 ICO, “Emerging coffee markets: South and East Asia,” (September 2018).
116 International Trade Centre, “The Coffee Exporter’s Guide,” (January 3, 2012), available at: http://www.

thecoffeeguide.org/coffee-guide/world-coffee-trade/domestic-consumption-in-producing-countries/ (last visited July 5, 2019).

117 “Coffee Consumption in Columbia Grew 33% in Five Years,” Colombian Coffee Insider, (December 2015), available at: https://www.federaciondecafeteros.org/algrano-fnc-en/index.php/comments/coffee_consumption_in_colombia_grew_33_in_five_years (last visited July 5, 2019).

118 Julian Hattem and Commentary, “One of the world’s top coffee exporters is on a mission to get locals to try drinking coffee,” Quartz Africa, (February 17, 2017), available at: https://qz.com/africa/913071/uganda-wants-locals-to-drink-more-coffee-by-supporting-local-starbucks-imitators/ (last visited July 5, 2019)

119 That comes in addition to the growth built-in the baseline scenario (that results from income growth and population growth)

120 We also assumed that demand will stabilize at the point when Japan stabilized which is 3.5 kg/ person, source: International Coffee Organization, “Coffee in China: International Coffee Council 115th Session, held at Milan, Italy, from 28 September to 2 October 2015,” (August 10, 2015), available at: http://www.ico.org/documents/cy2014-15/icc-115-7e-study-china.pdf (last visited August 12, 2019).

121 Sjoerd Panhuysen and Joost Pierrot, “Coffee Barometer 2018,” supra note 1; Gunning, Yvonne, et al., “16-O-methylcafestol is present in ground roast Arabica coffees: Implications for authenticity testing,” Food Chemistry v. 248 (2018), pp. 52–60 doi: 10.1016/j.foodchem.2017.12.034.

122 BASIC, “Coffee: The Hidden Crisis Behind the Success”, supra note 78.

123 TechNavio, “Global Coffee Pods Market 2019-2023,” (November 2018), available at: https://www.researchandmarkets.com/research/z8lkn2/global_coffee (last visited July 3, 2019).

124 Wikipedia Page on Nespresso, available at: https://en.wikipedia.org/wiki/Nespresso (last visited July 3, 2019).

125 A ‘cup’ is defined differently in different parts of the world ranging from 6 ounces to 8 ounces. Coffeestylish: How much coffee per cup, available at: https://coffeestylish.com/how-much-coffee/ (last visited July 3, 2019).

126 Ibid.; Black Bear Coffee Brewing Ratio Chart, available at: https://www.blackbearcoffee.com/resources/83 (last visited July 3, 2019).

127 For instance, in the US, the number of drinkers has increased by 10% between 2016 and 2017; this correlates with the fact that specialty drinkers consumed more per day in 2017 as compared to 2001 and with a growing market share for specialty coffee (source: Simran Sethi, “A Surprising New Trend In Coffee,” Forbes, (December 1, 2017), available at: https://www.forbes.com/sites/simransethi/2017/12/01/a-surprising-new-trend-in-coffee/#4a2172755b31 (last visited September 17, 2019); see also CBI Ministry of Foreign Affairs, “What is the demand for coffee in Europe?” (2018), available at: https://www.cbi.eu/market-information/coffee/trade-statistics/ (last visited September 17, 2019)).

128 Enveritas, “How many coffee farmers are there? Global coffee farm study,” (2018).

129 GISTEMP, “GISS Surface Temperature Analysis (GISTEMP).”

130 GISTEMP, “GISS Surface Temperature Analysis (GISTEMP),” supra note 107.

131 Robert J. Hijmans, Susan E. Cameron, Juan L. Parra, Peter G. Jones, and Andy Jarvis, “Very High Resolution Interpolated Climate Surfaces for Global Land Areas,” International Journal of Climatology, (2015), available at: https://doi.org/10.1002/joc.1276.

132 USAID Bureau for Food Security, “Country Data Sheets for Coffee Renovation and Rehabilitation,” (November 2017).

133 These three components are derived from the concept of sustainable development, which is economic development that is environmentally sustainable and socially inclusive.

134 World Coffee Producers Forum, available at: https://www.worldcoffeeproducersforum.com.br/en/forum/ (last visited September 17, 2019).

135 Some efforts have already been undertaken to map the SDGs onto sustainability endeavors in the coffee sector. For example, the Sustainable Coffee Challenge has identified four compass points for collective action among its working group: improve livelihoods, sustain supply, strengthen market demand, and conserve nature. For each compass point, the SCC identifies the applicable SDGs. Improving producer livelihoods aligns with SDG 1 No Poverty, SDG 2 Zero Hunger, SDG 3 Good Health and Well-Being, SDG 4 Quality Education, SDG 5 Gender Equality, and SDG 8 Decent Work and Economic Growth. Sustaining supply

and increasing market demand align with SDG 12 Responsible Consumption and Production and SDG 9 Industry, Innovation, and Infrastructure. Conserving Nature aligns with SDG 6 Clean Water and Sanitation, SDG 7 Affordable and Clean Energy, SDG 13 Climate Action, and SDG 15 Life on Land. Sustainable Coffee Challenge "Sustainability Progress Framework," Version 2.0 (June 27, 2019), p. 15-17, available at: https://www.sustaincoffee.org/assets/resources/Sustainability_Framework_9-28-17_bs.pdf (last visited July 2, 2019).

136 International Coffee Organization, "Achieving the Sustainable Development Goals in the Coffee Sector: Background Paper – ICO/ECF Symposium, held at Brussels, on 6 June 2019," supra note 23.

137 Luis Samper, Daniel Giovannucci, and Luciana Marques Vieira, "The Powerful Role of Intangibles in the Coffee Value Chain," supra note 4, p 3.

138 As recognized by SDG Target 1.4 and Indicator 1.4.2, ownership and control over land and resources, and tenure security, can help significantly in poverty reduction. While there are various reasons for this, one benefit of tenure security in some contexts is that it can improve access to formal credit or otherwise promote the use of credit. This is not always the case, however, and while academic research has drawn different conclusions, a review of the literature indicates that land titling has worked better in some geographies (e.g., Latin America), for larger farmers (particularly in Africa), and when the credit market is dominated by lenders requiring title for collateral. See e.g., R. López and Valdés, A, "Fighting rural poverty in Latin America: New evidence of the effects of education, demographics, and access to land," Economic Development and Cultural Change, (2000), 49(1), 197-211; L. J. Alston, Libecap, G. D., and Schneider, R, "The determinants and impact of property rights: Land titles on the Brazilian frontier," The Journal of Law, Economics, and Organization, (1996), 12(1), 25-61; S. R. Boucher, Barham, B. L., and Carter, M. R., "The impact of "market-friendly" reforms on credit and land markets in Honduras and Nicaragua," World Development, (2005), 33(1), 107-128; J. Calderón, "The formalisation of property in Peru 2001–2002: the case of Lima," Habitat International, (2004), 28(2), 289-300; D. Hunt, "Unintended consequences of land rights reform: the case of the 1998 Uganda Land Act," Development policy review, (2004), 22(2), 173-191; F. Place and Migot-Adholla, S. E., "The economic effects of land registration on smallholder farms in Kenya: evidence from Nyeri and Kakamega districts," Land Economics, (1998), pp. 360-373. Given the benefits of improving tenure security, the FNC has worked to increase the formal land tenure of coffee producers in Colombia (Source: Correspondence with producer association representative, September 12, 2019).

139 Specialty Coffee Association of America: Sustainability Council, "SCAA White Paper: A Blueprint to End Hunger in the Coffeelands," (2013), p 5, available at: https://scaa.org/PDF/SCAA-whitepaper-blueprint-end-hunger-coffeelands.pdf (last visited July 2, 2019); Katlyn S. Morris, V. Ernesto Mendez, and Meryl B. Olson, "'Los meses flacos': seasonal food insecurity in a Salvadoran organic coffee cooperative," The Journal of Peasant Studies, (2013), 40. 10.1080/03066150.2013.777708; Christopher Bacon, William Sundstrom, María Eugenia Flores Gómez, V. Ernesto Méndez, Rica Santos, Barbara Goldoftas, and Ian Dougherty, "Explaining the 'hungry farmer paradox': Smallholders and fair trade cooperatives navigate seasonality and change in Nicaragua's corn and coffee markets," Global Environmental Change, (2014), 25. 10.1016/j.gloenvcha.2014.02.005, available at: https://www.sciencedirect.com/science/article/abs/pii/S095937801400034X (last visited August 15, 2019).

140 See e.g., Sheridan, Michael "Addressing Hunger in the Coffeelands: The Next Great Sustainability Challenge in Specialty Coffee," SCA News, (April 10, 2012), available at: https://scanews.coffee/2012/04/10/addressing-hunger-in-the-coffeelands-the-next-great-sustainability-challenge-in-specialty-coffee/ (last visited July 2, 2019).

141 United Nations Sustainable Development Goals: Target 2.4, available at: https://www.un.org/sustainabledevelopment/hunger/ (last visited July 2, 2019).

142 Ibid., Targets 2.3, 2.4, 2.A.

143 For example, a review of the top 10 coffee-producing countries by volume (Brazil, Vietnam, Colombia, Indonesia, Ethiopia, Honduras, India, Uganda, Mexico, and Guatemala) shows that all ten countries are categorized as having significant or major challenges remaining towards achievement of this goal, despite all ten also showing a positive trend of incremental progress. The achievement gaps, and the specific health indicators that still need attention, vary by country. See e.g., Sustainable Development Solutions Network, and Bertelsmann Stiftung, "Sustainable Development Report 2019," (June 2019), pp.

19-37.

144 Ibid., pp. 233, 441.

145 Ibid., pp. 19-37.

146 International Coffee Organization, "Gender Equality in the Coffee Sector: An insight report," (2018), p. 9.

147 Ibid., p. 3.

148 Interview with coffee company representatives, June 13, 2019; see International Coffee Organization, "Gender Equality in the Coffee Sector: An insight report," supra note 156, p. 3.

149 Sustainable Development Solutions Network, and Bertelsmann Stiftung, "Sustainable Development Report 2019," supra note 153, pp. 19-37.

150 See e.g. International Labour Organization, "Code of practice on safety and health in agriculture: MESHA/2010/10, Geneva, 2010," (2010), Section 18, pp 162-66, available at: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_159457.pdf (last visited July 2, 2019) (describing welfare facilities, including water and toilets, that employers should provide to agricultural workers); International Labour Office, "Wash@Work: a Self-Training Handbook," (2016), pp 12-15, available at: http://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_535058.pdf (last visited July 3, 2019) (noting relevant provisions of ILO instruments focused on agriculture focused on water and sanitation).

151 For example, access to clean water for coffee farmers has been supported through co-financed water treatment programs run by Nespresso AAA Sustainable Quality. Sjoerd Panhuysen and Joost Pierrot, "Coffee Barometer 2018," supra note 1, p 22. It has also been supported through the use of premiums paid under certification schemes. Interview with coffee company representatives, June 13, 2019.

152 Among the top 20 coffee-producing countries, two have achieved affordable and clean energy: Brazil and Costa Rica. Four other countries are well on their way towards achieving SDG 7: Colombia, El Salvador, Peru, and Vietnam. The third tier of achievement, where "significant challenges remain" includes China, Guatemala, Honduras, Indonesia, and Nicaragua. The worst SDG 7 performance is concentrated primarily but not exclusively in Africa. The coffee-producing countries where affordable and clean energy remains a "major challenge" are Côte d'Ivoire, Ethiopia, India, Kenya, Mexico, Papua New Guinea, Tanzania, and Uganda. Sustainable Development Solutions Network, and Bertelsmann Stiftung, "Sustainable Development Report 2019," supra note 153 pp. 26-36. Some major coffee roasters already prioritize SDG 7, although some of their largest commitments to using modern sources of renewable energy are in consuming countries, rather than producing countries. In 2018, for example, Starbucks made a pledge to use 100% renewable energy within its retail stores by 2025; it relies on the Green-e certification to fulfill this commitment. Sustainalytics, "Second-Party Opinion: Starbucks Sustainability Bond," (2019), p. 6. Nestlé also has a long-term goal of moving to 100% renewable energy, although in 2017 it used only 25.7% renewable energy. Nestlé, "Nestle in Society: Creating Shared Value and Meeting Our Commitments 2017," (2017), p. 88.

153 See e.g. Verité. Project Coffee, supra note 8; Thomas Dietz, Janina Grabs, and Andrea Estrella Chong, "Mainstreamed voluntary sustainability standards and their effectiveness: evidence from the Honduran coffee sector" (2019) supra note 13, p. 9.

154 Blockchain technology could provide a more secure platform for traceability and transparency throughout the coffee supply chain, providing the ability to trace coffee back to the farmer. It creates a record of transactions that is accessible by all parties. IBM has also piloted blockchain for labor compliance purposes. With IBM Blockchain Trusted Identity, all workers get a trusted identification and plantation owners can create and record a labor contract that specifies information such as payment terms, expected work hours or output, contract length, and labor conditions; Widdifield, John, "Brewing blockchain: Tracing ethically sourced coffee," IBM, August 8, 2018, available at: https://www.ibm.com/blogs/blockchain/2018/08/brewing-blockchain-tracing-ethically-sourced-coffee/ (last visited July 3, 2019). Given current limited broadband penetration, blockchain technologies might remain inaccessible to many smallholder farmers, however. Moreover, in some situations, blockchain itself is not necessary for achieving these results.

155 Will Steffen, et al., "Planetary boundaries: Guiding human development on a changing planet," Science, February 13, 2015, available at: https://science.sciencemag.org/content/347/6223/1259855 (last visited July 3, 2019).

156 See e.g. World Research Institute, "How to Sustainably Feed 10 Billion People by 2050, in 21 Charts,"

(December 5, 2018), available at: https://www.wri.org/blog/2018/12/how-sustainably-feed-10-billion-people-2050-21-charts (last visited July 2, 2019) (Noting that sustainably feeding the anticipated global population by 2050, while also reducing greenhouse gas emissions from agriculture, will require among other things significant efforts to reduce growth in demand for food and other agricultural products).

157 See e.g., Christian Bunn, Mark Lundy, Peter Läderach, Evan Girvetz, and Fabio Castro, "Climate Smart coffee in Honduras," (2018), supra note 109; Holland, Tim, Oliver Coomes, and Brian Robinson. "Evolving frontier land markets and the opportunity cost of sparing forests in western Amazonia," Land Use Policy Volume 58, p.458 (2016); Meyfrodt, Patrick, Tan Phuong Vu, and Viet Anh Hong, "Trajectories of deforestation, coffee expansion, and displacement of shifting cultivation in the central highlands of Vietnam," 23(5) Global Environmental Change (2013), p. 1187; Gemecho Ango, Tola, "'Medium-scale' forestland grabbing in the southwestern highlands of Ethiopia: Impacts on local livelihood and forest conservation," 7(24) Land (2018), p. 6; Newman, Minke, Kurt McLaren, and Byron Wilson, "Using the forest transition model and a proximate cause of deforestation to explain long-term forest cover trends in a Caribbean forest," 71 Land Use Policy 395-408 (2018), p. 405.

158 The Task Force on Justice, "Justice for All," (April 2019) available at: https://cic.nyu.edu/sites/default/files/task_force_on_justice_report_conf_version_29apr19_1_1_1_compressed.pdf, p.12 (last visited July 1, 2019).

159 Examples of specific justice solutions within coffee value chains include, for example: legal representation for farmers and cooperatives as needed in dealings with buyers; farmers' and workers' access to processes to enforce contractual or legal obligations and to lodge grievances if relevant; legal education and empowerment that support both farmers and workers in protecting their rights; eradication of slavery-like working conditions; improved accountability of justice systems in coffee-producing regions; and access to legal protections related to land tenure or employment.

160 For example, the UN Guiding Principles on Business and Human Rights, a soft law instrument that has the weight of quasi-legal rules used to interpret binding international law, assert the responsibility of business enterprises to respect human rights, and describe particular actions that can be taken to fulfill this responsibility. Applying these Guiding Principles in the context of the SDGs, which also are aligned with international human rights law, and in particular SDG 17, implies that business actors have full co-responsibility for achievement of the SDGs.

161 Global Coffee Platform, available at: https://www.globalcoffeeplatform.org/accelerate-your-coffee-sustainability (last visited July 1, 2019).

162 Sustainable Coffee Challenge, available at: https://www.sustaincoffee.org/ (last visited July 2, 2019).

163 Sustainable Coffee Challenge Framework, available at: https://www.sustaincoffee.org/framework/ (last visited July 2, 2019).

164 Sustainable Coffee Challenge, supra note 172.

165 Sustainable Coffee Challenge Commitments, available at: https://www.sustaincoffee.org/commitments/ (last visited July 2, 2019).

166 Global Coffee Platform, The Coffee Data. Standard, available at: https://www.globalcoffeeplatform.org/latest/2019/a-common-language-for-sustainable-coffee-the-coffee-data-standard#newsheader (last visited Sept. 4, 2019).

167 Global Coffee Platform, The Coffee Data. Standard, available at: https://www.globalcoffeeplatform.org/latest/2019/a-common-language-for-sustainable-coffee-the-coffee-data-standard#newsheader (last visited Sept. 4, 2019).

168 This point arose in interviews both with company representatives and with research institutes working on coffee, who flagged frustration with the fragmentation of efforts and noted that, among other things, this split made it difficult to know where to put their efforts, and raised concerns about duplication, inefficiencies, and effectiveness. Interview with coffee company representatives, June 14, 2019; Interview with research institute representative, May 28, 2019; Interview with research institute representatives, May 6, 2019.

169 This point arose in interviews both with company representatives and with research institutes working on coffee, who flagged frustration with the fragmentation of efforts and noted that, among other things, this split made it difficult to know where to put their efforts, and raised concerns about duplication,

inefficiencies, and effectiveness. Interview with coffee company representatives, June 14, 2019; Interview with research institute representative, May 28, 2019; Interview with research institute representatives, May 6, 2019.

170 For example, Mitiku et al. found that in Ethiopia, Rainforest Alliance and Fairtrade-Organic certifications were associated with higher incomes, Fairtrade certification alone had little impact, and Organic certification alone was associated with reduced incomes. Fikadu Mitiku, Yann de Mey, Jan Nyssen, and Miet Maertens, "Do Private Sustainability Standards Contribute to Income Growth and Poverty Alleviation? A Comparison of Different Coffee Certification Schemes in Ethiopia," (2017) Sustainability, 9, 246. The expansion of group certification raises questions about how much oversight certifications really provide: in Uganda, 8 Rainforest Alliance certificates cover 23,564 farms. Dana Newsome and Jeffrey Milder, "2018 Rainforest Alliance Impacts Report," (2018) pp. 69-70. Some researchers have argued that while certification can be positive for cooperative members, it can be associated with lower wages for workers employed on certified farms than for those employed on uncertified farms. Carlos Oya, Florian Schaefer, Dafni Skalidou, Catherine McCosker, and Laurenz Langer, "Effects of certification schemes for agricultural production on socio-economic outcomes in low-and middle-income countries: a systematic review," A Campbell Systematic Review (2017), 3, p. 9. In a review of 24 statistically rigorous studies comparing certified and non-certified farms, Ruth DeFries of Columbia University found that for 58% of variables, certification had no significant impact on sustainability, while for 34% of variables, there was a positive effect, and for 8% of variables, a negative effect. What positive impacts have been found are more often in terms of environmental (ecosystem conservation) and economic (revenue) sustainability, rather than on social sustainability. Ruth DeFries, Jessica Fanzo, Pinki Mondal, Roseline Remans, and Stephen Wood, "Is voluntary certification of tropical agricultural commodities achieving sustainability goals for small-scale producers?" Environmental Research Letters, (2017), 12 (033001), p. 3. Certification is often significantly associated with increases coffee income, but often does not significantly increase total household income. W. Vellema, A. Buritica, C. Gonzalez, M. D'Haese, "The effect of specialty coffee certification on household livelihood strategies and specialization," Food Policy 57, (2015), p. 20; Carlos Oya, Florian Schaefer, Dafni Skalidou, Catherine McCosker, and Laurenz Langer, "Effects of certification schemes for agricultural production on socio-economic outcomes in low-and middle-income countries: a systematic review" A Campbell Systematic Review, 3, (2017), p. 9; Tina Beuchelt and Manfred Zeller, "Profits and poverty: certification's troubled link for Nicaragua's organic and fairtrade coffee producers," Ecological Economics, 70, (2011), p. 1316.

171 Sjoerd Panhuysen and Joost Pierrot, "Coffee Barometer 2018," supra note 1, p 19. In addition, because some certification schemes allow their labels to be put on blends that also include non-certified coffee, some brands have been able to sell coffee with a certification label even when less than 50% of the beans were actually certified. For example, Rainforest Alliance allows brands that blend with 30% Rainforest Alliance coffee to use its label, if the brand has a plan to scale-up the percentage of Rainforest Alliance-certified beans in the blend over time to 100%, and if it discloses on the package what the Rainforest Alliance percentage is. The recommended annual scale-up is by 15%, but that is not mandatory—companies can come up with their own timeframe with Rainforest Alliance. Rainforest Alliance, "Requirements and Guideline for Use of Rainforest Alliance Trademarks," (2016), p. 17, available at: https://www.rainforest-alliance.org/business/wp-content/uploads/2018/07/rainforest-alliance-marks-guide.pdf ; see also PBS Independent Films: Black Gold, available at: https://www.pbs.org/independentlens/blackgold/yuban.html.

172 The 4C standard was developed to ensure that all coffee companies comply with a minimum sustainability standard. 4C Baseline license has lower requirements in all areas of sustainability and is considered the weakest verification/license system among all sustainability standards. Dietz, Thomas et al., "The Voluntary Coffee Standard Index (VOCSI). Developing a composite index to assess and compare the strength of mainstream voluntary sustainability standards in the global coffee industry," Ecological Economics, Volume 150 pp. 72-87 (2018), pp. 82-83. A 2019 study of 659 farms in Honduras found that 4C was a sustainability program likely to show evidence of decoupling: practices on the ground departing from stated institutional norms. The most robust changes in practice among 4C farmers compared to non-certified farmers were that they were more likely to have a first aid kit at the farm, and were more likely to prohibit synthetic chemicals. Workers on average made US 5 cents less per day on 4C farms than on non-certified farms.

Among other things, the authors conclude that UTZ and 4C both have little impact on practices at the farm level, despite UTZ having a strict standard on paper. Thomas Dietz, Janina Grabs, and Andrea Estrella Chong, "Mainstreamed voluntary sustainability standards and their effectiveness: evidence from the Honduran coffee sector" (2019), supra note 13.

173 Companies that rely on internal standards tend to argue that proprietary sustainability standards work more efficiently along multiple levels of their supply chain and are more tailored towards quality improvements. While there are benefits, there are also risks. For example, one risk is that movement away from third-party auditing makes it less likely that abusive labor practices will be held in check, in countries with weak government oversight.

174 The partnership between TechnoServe and Nespresso is one prominent example of a partnership between a company and non-profit. Source: TechnoServe, "Technoserve and Nespresso partner to build a more sustainable coffee industry in East Africa," July 16, 2013, available at: https://www.technoserve.org/press-room/detail/technoserve-and-nespresso-partner-to-build-a-more-sustainable-coffee-indust (last visited September 17, 2019). Several interviewees discussed efforts by companies to leverage donor finance in support of projects they help to finance. Interview with company representatives, June 14; Interview with company representatives, June 13; Interview with non-profit representative, June 14.

175 See e.g. Starbucks, "Committed to 100% Ethically Sourced," available at: https://www.starbucks.com/responsibility/community/farmer-support/farmer-loan-programs (last visited July 2, 2019). ("We are committed to not only increasing our own C.A.F.E. Practices purchases, but also to making the program available to the entire coffee industry – even competitors. We opt for an "open-source" approach, sharing our tools, best practices and resources to help all producers make improvements in the long-term sustainability of their farms.").

176 Sjoerd Panhuysen and Joost Pierrot, "Coffee Barometer 2018," supra note 1, pp. 24-25.

177 Sjoerd Panhuysen and Joost Pierrot, "Coffee Barometer 2018," supra note 1, pp. 22-25.

178 Business Call to Action, "Vava Coffee," BCtA Impact Measurement Services (BIMS) Case Study, (2017), available at: https://www.businesscalltoaction.org/sites/default/files/resources/BIMSCaseStudy_VavaCoffee_web_5-11-17.pdf; Vava Coffee, Vava Coffee 2017 Spring Update & 2016 Recap (2017); Esha Chhabra, "This Kenyan Female Founder Wants to Radically Change the Coffee Industry," Forbes, August 8, 2018.

179 FNC, "Ecomill: A New, Cleaner Technology for Coffee Processing, Now Available to Colombian Coffee Growers," June 5, 2013, available at: https://www.federaciondecafeteros.org/particulares/en/sala_de_prensa/detalle/ecomill_a_new_cleaner_technology_for_coffee_processing_now_available_to_col/.

180 Sjoerd Panhuysen and Joost Pierrot, "Coffee Barometer 2018," supra note 1, p. 16.

181 Interview with company representative, April 17, 2019.

182 Interview with producers, July 11, 2019; Interview with academic, July 31, 2019.

183 In particular, the extended payment terms imposed by companies owned by JAB Holding onto traders, which have gone from 30 days to 300 days, have strong potential to create downward pressure that ultimately affects producers. "JAB upends coffee trading," The Economist, February 23, 2019, available at: https://www.economist.com/business/2019/02/23/jab-upends-coffee-trading; Interview with producers, July 11, 2019; Interview with industry association representative, July 19, 2019; Interview with academic, July 31, 2019. Not everyone interviewed agreed that the terms affected producers, however, noting that the traders have been able to bear these terms through the use of third-party financing. Interview with company representative, July 16, 2019. Yet even third-party financing comes with a cost that ultimately will be born either by the traders and/or the producers. For more on the changes to terms, see e.g., Isis Almeida and Marvin G Perez, "Buy Now, Pay Later Helps JAB Billionaires Build Beverage Empire," Bloomberg Businessweek, January 29, 2018, available at: https://www.bloomberg.com/news/articles/2018-01-30/buy-now-pay-later-helps-jab-billionaires-build-beverage-empire.

184 As noted by the ICO, economic viability requires "farmers' ability to sustain their coffee growing operation on the basis of current and projected revenues equal to or in excess of current and planned expenditures, i.e. costs." Such costs include both variable costs and fixed costs, including depreciation. International Coffee Organization, "Assessing the economic sustainability of coffee growing: International Coffee Council 117th Session, held at London, United Kingdom, from 19 to 23 September 2016," p 4, supra note 4.

185 In Africa, farm sizes are shrinking over time, getting sometimes as small as 0.15 ha, see T.S., Jayne, Jordan Chamberlin, and Derek Headey, "Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis," Volume 48 (October 2014), pp. 1-17, available at: https://www.sciencedirect.com/science/article/pii/S0306919214000888 (last visited August 12, 2019), and AFCA, "Creating sustainable coffee industries in Africa; Why won't coffee roasters just pay higher prices?" (February 15, 2018), available here: https://afca.coffee/wp-content/uploads/presentations/16AFCCE/S3/Paul%20Stewart.pdf?boxtype=pdf&g=false&s=false&s2=false&r=wide (last visited August 12, 2019).

186 International Coffee Organization, "Assessing the economic sustainability of coffee growing: International Coffee Council 117th Session, held at London, United Kingdom, from 19 to 23 September 2016," supra note 4, which includes unpaid labor as a cost of production that should be included when assessing coffee farming profitability in light of the full economic costs of production.

187 The Living Income: Community of Practice, "The Concept," available at: https://www.living-income.com/the-concept (last visited August 12, 2019).

188 Ibid.

189 Ibid.

190 Christian Bunn, Mark Lundy, Peter Läderach, Evan Girvetz, and Fabio Castro, "Climate Smart coffee in Honduras," (2018), supra note 109.

191 United Nations, "Sustainable Development Goal 8," (2019), available at: https://sustainabledevelopment.un.org/sdg8 (last visited August 12, 2019); see also Martha Anker and Richard Anker, "Living Wages Around the World," (January 27, 2017), Chapter 1, available at: https://www.elgaronline.com/view/9781786431455/chapter01.xhtml#fn1 (last visited August 12, 2019). ("Decent work is not possible without decent wages.")

192 CFS, "Principles for Responsible Investment In Agriculture and Food Systems," rai 22(iii), available at: http://www.fao.org/3/a-au866e.pdf (last visited August 12, 2019); Martha Anker and Richard Anker, "Living Wages Around the World," (January 27, 2017), supra note 142 ("there is general agreement that a living wage … is a right according to the international community"). Living wages are also reflected in 4C's green (high) standard for wage, 4C Services GmbH, "The Common Code for the Coffee Community (4C) Code of Conduct," (November 2018), available at https://documentcloud.adobe.com/link/track?uri=urn%3Aaaid%3Ascds%3AUS%3A3471bed2-6d19-4e76-bf1d-c4fce44f2a2b (last visited August 13, 2019).

193 Martha Anker and Richard Anker, "Living Wages Around the World," (January 27, 2017), supra note 142 (citing GLWC consensus definition).

194 Jacobs Douwe Egberts IDH Farm Fit Fund, available at: https://www.jacobsdouweegberts.com/company-news/idh-farm-fit-fund/ (last visited July 3, 2019).

195 Ibid., p. 31, 33.

196 Ibid., p. 45, 48.

197 IDH. (2017). Driving Innovations in Smallholder Engagement, p. 60.

198 Ibid., p. 49.

199 Ibid., p. 53.

200 World Coffee Research, "The Future of Coffee," available at: https://worldcoffeeresearch.org/ (last visited July 3, 2019).

201 See list of participating companies and others here: https://worldcoffeeresearch.org/about/.

202 Numbers are not disclosed for Nespresso's AAA.

203 BASIC, "Coffee: The Hidden Crisis Behind the Success", supra note 78.

204 Transparent Trade Coffee, "2018 Specialty Coffee Transaction Guide," Emory University, (December 2018), available at: https://www.transactionguide.coffee/home/en/ (last visited August 13, 2019).

205 Interview with company representative, July 16, 2019.

206 One small trader of specialty coffee noted that costs of production information has also been helpful in negotiations with specialty buyers, and helps to ensure that prices are never set too low. Interview with trader and entrepreneur, July 25, 2019.

207 Global Coffee Report, "World Coffee Producers Forum Releases Final Declaration," July 11, 2019, available at: http://gcrmag.com/news/article/world-coffee-producers-forum-releases-final-declaration.

208 BASIC, "Coffee: The Hidden Crisis Behind the Success,", supra note 78, p. 161.

209 To assess the SDG track record in the coffee-growing regions, NCSPs could use methodologies developed by the UN Sustainable Development Solution Network. Sustainable Development Solutions Network, Getting. Started with SDG Implementation, available at: http://unsdsn.org/what-we-do/sustainable-development-goals/getting-started-with-sdg-implementation/ (last visited July 3, 2019).
210 The 100 – 100 Plan is a national coffee sustainability plan for Colombia, the development of which started in 2016. The plan aims to make 100% of the country's coffee farms sustainable by 2027, which is the centennial of the FNC. Stakeholders will soon begin to design the implementation plan. Correspondence with producer association representative, September 12, 2019.
211 Christian Bunn, Mark Lundy, Peter Läderach, Evan Girvetz, and Fabio Castro, "Climate Smart coffee in Honduras," (2018), supra note 109, p. 10.
212 For example, the CalcuCafé tool that has been piloted with coffee cooperatives in Peru. Gilly Leshed, Masha Rosca, Michael Huang, Liza Mansbach, Yicheng Zhu, and Juan Nicolás Hernández-Aguilera, "CalcuCafé: Designing for Collaboration Among Coffee Farmers to Calculate Costs of Production," Proceedings of the ACM on Human-Computer Interaction – CSCW, Volume 2 (November 2018).
213 Certain efforts to increase productivity could undermine environmental sustainability. This suggests that, in some contexts, producers might be better off seeking to compete on quality rather than productivity. Producing high-quality, organic coffee could be more profitable and sustainable, while ensuring a healthy environment also supports complex, fine taste. In addition, some environmental practices are also shown to improve productivity, for example by increasing natural pollinators and, in some areas, engaging in inter-cropping.
214 For example, the Global Coffee Platform and the Sustainable Coffee Challenge.
215 The Global Fund to Fight AIDS, Tuberculosis and Malaria has a 3-year funding cycle.
216 The Global Fund Funding Model, available at: https://www.theglobalfund.org/en/funding-model/throughout-the-cycle/financial-management-strengthening/ (last visited July 3, 2019).
217 Ibid.
218 Vitor Gaspar, et al., "Fiscal Policy and Development: Human, Social, and Physical Investments for the SDGs," International Monetary Fund Staff Discussion Notes, No. 19/03 (January 23, 2019).
219 Forthcoming study. See announcement at http://unsdsn.org/news/2018/10/02/sdsns-sdg-financing-team-presents-preliminary-findings-on-sdg-costs-for-lidcs-with-imf-at-unga-73/.
220 Move Humanity, Closing the SDG Budget Gap, Sustainable Development Solutions Network, (2018), available at: http://unsdsn.org/wp-content/uploads/2019/02/MOVE-HUMANITY-REPORT-WEB-V7-190319.pdf.
221 Enveritas, "How many coffee farmers are there? Global coffee farm study," (2018).
222 International Coffee Organization, "Record exports in coffee year 2017/18" (November 9, 2018), available at: http://www.ico.org/show_news.asp?id=675 (last visited July 5, 2019).
223 Taking into account a weight loss of 20% during roasting and an 8oz cup, we are using 70 and 140 cups per kg (Source: "How many coffee cups can I get from 1kg of beans?" (May 1, 2018), available at: https://www.shopcoffee.co.uk/coffee/many-cups-1kg-coffee-beans/ (last visited July 5, 2019)
224 OECD, "Blended Finance," available at: http://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/blended-finance.htm (last visited September 16, 2019).
225 International Finance Corporation, "Nicaragua: Brewing up a solution to the coffee challenge," available at: https://www.ifc.org/wps/wcm/connect/82d0dd004a510987bccfbf10cc70d6a1/NICARAGUA_Brewing+up+a+solution+to+the+coffee+rust+challenge+.pdf?MOD=AJPERES (last visited July 3, 2019).
226 International Finance Corporation, "Ethiopia: Connecting coffee farmers to market," available at: https://www.ifc.org/wps/wcm/connect/90365f80470b50beb031fc57143498e5/Ethiopian+Coffee+II_rev.pdf?MOD=AJPERES (last visited July 3, 2019).
227 In the United States, Congress has mandated check-off programs for over 20 agricultural commodities. These marketing programs are funded through deductions from sales by producers, marketers, and/or importers; they are generally used to pay for advertising campaigns (which can benefit producers by stimulating general demand for their products) and research. Geoffrey Becker, "Federal Farm Promotion ('Check-Off') Programs," CRS Report for Congress, (2005), p.3.
228 In addition, the use of a check-off program for the Global Coffee Fund cannot displace contributions to

WCR, which provides a critical service to the coffee sector in light of likely climate impacts.

229 Brown, Nick, "Starbucks Committing $20 Million to Farmer Assistance Amid Price Crisis," Daily Coffee News, September 25, 2018.

230 See e.g., Gilly Leshed, Masha Rosca, Michael Huang, Liza Mansbach, Yicheng Zhu, and Juan Nicolás Hernández-Aguilera, "CalcuCafé: Designing for Collaboration Among Coffee Farmers to Calculate Costs of Production," Proceedings of the ACM on Human-Computer Interaction – CSCW, Volume 2 (November 2018).

231 Ousmane Badiane, "The Twenty-First Century agricultural cooperative: Increasing the business credibility of smallholders," International Food Policy Research Institute, January 21, 2016, available at: http://www.ifpri.org/blog/twenty-first-century-agricultural-cooperative-increasing-business-credibility-smallholders (last visited September 17, 2019); Development of Cooperatives in Latin America, Monthly Labor Review, vol. 52, no. 4, (1941), pp. 810-816. JSTOR, available at: https://www.jstor.org/stable/41817646?seq=1#page_scan_tab_contents.

232 Estimates vary depending on the value chain and exporting country, as well as what final product one is considering. For a retail price of $3-4 per 8 oz cup at a specialty shop, and a farmgate price of $1 per pound, and assuming 25 cups per pound, a farmer would only receive 1-2% of the final retail price.

233 Whether all of the earnings of various entities along the value chain are fairly apportioned based on their respective "value addition" or are also due to "value capture" that results from market power and power imbalances (see Section II) is an important question that is outside the scope of this discussion.

234 Interview with coffee company representative, June 13, 2019.

235 An analogous example can be drawn from the timber industry. In Mozambique, the government enacted an export ban on non-processed first-class timber in an effort to force value addition and local employment at origin. Yet the ban had the unintended effect of making the timber less valuable, as the dominant Chinese buyers of Mozambican timber had strong preferences for logs over processed timber. Kaitlin Cordes, Olle Ostensson, and Perrine Toledano, "Employment from Mining and Agricultural Investments: How Much Myth, How Much Reality?" Columbia Center on Sustainable Investment (July 2016), pp 94-95.

236 The way geographical designations are granted legal protection differs in the EU and USA. While the EU protects GIs of foodstuffs and agricultural products using Protected Designation of Origins (PDO) or Protected Geographic Indications (PGI), the US allows for a non-generic geographic term to be registered as a certification mark or trademark by incorporating the GIs into existing trademark regimes. For single-origin coffee, if geographic terms have 'acquired distinctiveness,' they can be registered in all major coffee markets including the USA, EU and other countries such as Japan, as trademarks. However, if it does not have 'acquired distinctiveness,' it may be protected only as a certification mark/trademark in the USA and EU (while Japan would allow to grant PDO/PGI). Trademarks differ from GIs by the fact that trademarks relate to the producer of a product or service and are owned by a particular enterprise, whereas GIs relate to the place of origin and its characteristics and can be used by anyone in compliance with the standards. Ethiopia uses a mix of both concepts. Source: Aslihan Arslan and Christopher Reicher, "The Effects of the Coffee Trademarking Initiative and Starbucks Publicity on Export Prices of Ethiopian Coffee," Journal of African Economies, Volume 20, Issue 5, (November 2011), pp 704–736, available at: https://academic.oup.com/jae/article-abstract/20/5/704/734489?redirectedFrom=fulltext (last visited August 12, 2019).

237 Ibid.

238 Luis Samper and Xiomara Quiñones-Ruiz, "Towards a Balanced Sustainability Vision for the Coffee Industry," (April 5, 2017), available at: https://doi.org/10.3390/resources6020017 (last visited August 15, 2019).

239 Aslihan Arslan and Christopher Reicher, "The Effects of the Coffee Trademarking Initiative and Starbucks Publicity on Export Prices of Ethiopian Coffee," supra note 265.

240 Ibid.

241 Ibid.

242 Luis Samper and Xiomara Quiñones-Ruiz, "Towards a Balanced Sustainability Vision for the Coffee Industry," (April 5, 2017), supra note 267.

243 Turner, Amanda, "Is Roasting Your Own Coffee Beans Worth the Time & Effort?" Coffee Channel, (April 6, 2019), available at: https://coffee-channel.com/is-roasting-your-own-coffee-beans-worth-the-time-effort/ (last visited August 15, 2019); Sweet Maria's Coffee Library, available at: https://legacy.sweetmarias.com/

library/category/roast/getting-started/ (last visited August 15, 2019); Kenneth Davids, "Home Coffee Roasting, Revised, Updated Edition: Romance and Revival," (November 20, 2003) available at: https://www.amazon.com/Coffee-Roasting-Revised-Updated-Edition/dp/0312312199/ (last visited August 15, 2019); McMahen, Ben, "Roasting your own coffee is cheap, easy and delicious," (September 14, 2016), available at: https://medium.com/@benmcmahen/roasting-your-own-coffee-is-cheap-easy-and-delicious-6843ef18fe30 (last visited August 15, 2019).

244 Interview with coffee expert, August 28, 2018.

245 Ibid., p. 4.

246 Ibid., p. 2.

247 Interview with coffee industry consultant, August 5, 2019.

248 Interview with coffee industry association representative, July 19, 2019.

249 Unleashed Coffee, "The Unleased Duo," available at: https://unleashedcoffee.com/our-story/ (last visited on August 15, 2019).

250 LaPorte, Nicol, "Coffee's Economics, Rewritten by Farmers," The New York Times, (March 16, 2013), p. BU1.

251 Ibid., p. BU1.

252 Interview with coffee company representative, July 16, 2019.

253 Ibid. One example of a high-quality specialty company with deep roots in an origin country is Devocion, which sources exclusively from Colombia and roasts directly in the United States. Devoción, "Our Story," available at: https://www.devocion.com/pages/our-story (last visited August 15, 2019).

254 Interview with coffee industry consultant, August 5, 2019 (noting that, for example, in the morning, a consumer might drink cheaper coffee as a "caffeine experience" before rushing out the door, whereas later in the day, the same consumer might meet friends at a specialty coffee shop for a different experience). See also Leslie Patton, "Coffee Snobs are Shelling Out $3.25 for a Jolt of Instant," Bloomberg, Sept. 6, 2019 (describing the "'second-cup' problem," in which consumers want more caffeine but not necessarily the same coffee experience as earlier in the day).

255 Killian Stokes and Shane Reilly, "Radically good coffee with radical impact," Blockchain Expo World Series, (2019), p. 1.

256 Moyee, "Annex Moyee Impact Report," (2015), p. 12, available at: https://www.moyeecoffee.com/wp-content/uploads/2018/02/Annex-Moyee-Impact-Report.pdf (last visited August 15, 2019).

257 Ibid., p.12.

258 Moyee Coffee Ethiopia Clients, available at: https://www.moyeeethiopia.com/clients (last visited August 15, 2019).

259 Moyee Coffee Ethiopia Sales, available at: https://www.moyeeethiopia.com/sales (last visited August 15, 2019).

260 Laura Stevens, "Amazon Expands Into Ocean Freight," Wall Street Journal, (January 25, 2017), available at: https://www.wsj.com/articles/amazon-expands-into-ocean-freight-1485357884?ns=prod/accounts-wsj (last visited August 15, 2019).

261 Amazon Fulfilment Page, available at: https://services.amazon.com/fulfillment-by-amazon/benefits.htm (last visited August 15, 2019).

262 Isabela Minondo, "A Producer's Guide to Preparing Coffees for Export," Perfect Daily Grind, (2018), p. 1.

263 Electronic World Trade Platform Introduction, available at: https://www.ewtp.org/about/introduction.html (last visited August 15, 2019). "EWTP will incubate rules for the development of eTrade in terms of industry standards and rules, simplification of regulations and customs processes, evolution of consumer protection, lowering of tariffs, harmonization of taxation, development of internet and logistics infrastructure, facilitation of flow of goods, finance and data."

264 Electronic World Trade Platform Home Page, available at: https://www.ewtp.org/ (last visited August 15, 2019).

265 Alibaba.com Rwanda Coffee Beans Search Results, available here: https://www.alibaba.com/showroom/rwanda-coffee-beans.html (last visited August 15, 2019).

266 Moses Gahigi, "Coffee sales on Alibaba to rise," Rwanda Today, (February 20, 2019), available at: http://rwandatoday.africa/business/Coffee-sales-on-Alibaba-to-rise/4383192-4990718-11oa523/index.html (last

visited August 15, 2019).

267 Examples are Cafe Maraba, grown by the Abahuzamugambi ba kawa (United for coffee) farmers cooperative is sold directly by an umbrella farmer organization, the Rwanda Small Holder Specialty Coffee Company (RWASHOSCCO), which is comprised of 11 member cooperatives (Source: "Rwanda – 'Increasing quality and value in the Rwanda coffee sector,"' Rwanda Small Holder Specialty Coffee Company (RWASHOSCCO), (2005), available at: http://siteresources.worldbank.org/KFDLP/Resources/461197-1199907090464/4554803-1210107115154/Rwanda2.pdf (last visited August 15, 2019)), Question Coffee is produced by the cooperative Dukunde Kawa and exported by the Relationship Coffee Institute, which was formed by the American organization Sustainable Harvest with support from Bloomberg Philanthropies (See https://www.bizjournals.com/portland/blog/sbo/2015/10/portlands-sustainable-harvest-creates-coffee.html and http://www.relationshipcoffeeinstitute.org/about/our-mission), -Gorilla Coffee, which is owned by Rwanda Farmers Coffee Company and that sources from multiple cooperatives and washing stations (http://africajumpstart.com/wp-content/uploads/2016/10/Rwanda-Coffee-Farmers-Co.-presentation.pdf).

268 Moses Gahigi, "Coffee sales on Alibaba to rise," (February 20, 2019), supra note 295.

269 "Price supports do little to help farmers with below-average incomes because benefits are distributed in proportion to sales." Robert Thompson, "Agricultural. Price Supports," The Concise Encyclopedia. Of Economics, available at: http://www.econlib.org/library/Enc1/AgriculturalPriceSupports.html (last visited July 3, 2019).

270 Mary Burfisher and Jeffrey Hopkins, "Decoupled Payments: Household Income Transfers in Contemporary U.S. Agriculture," USDA, Agricultural Economic Report No. 822 (February, 2003), p. 3.

271 Christopher Gilbert, "International commodity agreements: An obituary notice," 24(1) World Development 1-19 (1996).

272 Varangis, Panos, et al, "Dealing with the Coffee Crisis in Central America: Impacts and Strategies," The World Bank Development Research Group. Policy Research Working Paper No. 2993 (2003).

273 A 2014 World Bank study showed that 40 Sub-Saharan African countries operated an unconditional cash transfer program; worldwide, it is estimated that more than one billion people benefit from such programs in low- and middle-income countries. (Source: United Nations. University, "Rates. Of Return to Social Protection: Social Cash Transfers in Uganda," United Nations University Policy Brief Number 2 (2018).)

274 This World Bank's "Identification 4 Development" program assists countries in developing a national ID system with good governance principles, and with the help of critical technology and funding partners such as GSMA, Omidyar, USAID through the Digital Impact Alliance (DIAL). Moreover, the World Bank has developed a cost model to help understand the cost drivers behind developing an ID system. This model could be usefully leveraged to optimize the development of the coffee farmer roster. (Source: The World Bank Identification For Development, available at, http://id4d.worldbank.org (last visited. July. 3, 2019).)

275 For instance, in Nigeria, as part of its mandate to create and operate the country's first central National Identity Database, the Nigerian Identity Management Commission (NIMC) has partnered with a series of corporate partners to issue MasterCard-branded identity cards with an electronic payment solution for 13 million Nigerians in the pilot phase (and 167 million citizens ultimately), making it the broadest financial inclusion program in Africa. (Source: Press Release: MasterCard-Branded National eID Card Launched in Nigeria, available at, https://newsroom.mastercard.com/press-releases/mastercard-branded-national-eid-card-launched-nigeria/ (last visited July 2, 2019).)

276 While globally, around 1.7 billion people still lack access to convenient financial services, 31 emerging markets have improved considerably their financial inclusion rates, "which can be attributed to simultaneous growth in active mobile money use". In sub-Saharan Africa, over 60 per cent of the adult population has a mobile money account. (Source: GSMA, "State of the Industry Report on Mobile Money," (2018).)

277 The quantification is based on 2017 GCP study.

278 Adapted from The Global Fund Funding Model, Ibid.

279 Enveritas (2018) How many coffee farmers are there? Global coffee farm study.

280 Global Coffee Platform, "A quick scan on improving the economic viability of coffee farming" available at: https://www.globalcoffeeplatform.org/

resources/a-quick-scan-on-improving-the-economic-viability-of-coffee-farming (last visited July 3, 2019).
281 Sjoerd Panhuysen and Joost Pierrot, “Coffee Barometer 2018,” supra note 1.
282 UC Davis and Basis, “Feed the Future Innovation Lab for Markets, Risk and Resilience,” (2010), available at: https://basis.ucdavis.edu/project/index-based-weather-insurance-coffee-cooperatives-guatemala (last visited August 14, 2019).
283 Souha Ouni, “New Tool Shows Promise For Index Insurance To Reach More Farmers,” International Research Institute for Climate and Society: Financial Instruments, February 2, 2017, available at: https://medium.com/insideindex-insurance/new-tool-shows-promise-for-index-insurance-to-reach-more-farmers-f6e90ae13d7a (last visited August 14, 2019).
284 Dan Osgood, “New Climate Data Transforms Insurance Projects in Africa,” International Research Institute for Climate and Society, April 12, 2017, available at: https://iri.columbia.edu/news/enacts-transforms-insurance-projects-in-africa/ (last visited August 14, 2019).
285 UC Davis and Basis, “Feed the Future Innovation Lab for Markets, Risk and Resilience,” (2010), supra note 240.
286 Elisabeth Gawthrop, “After Ten Years of Index Insurance, What’s Next?” International Research Institute for Climate and Society, October 16, 2018, available at: https://iri.columbia.edu/news/after-ten-years-of-index-insurance-whats-next/ (last visited August 14, 2019).
287 Elisabeth Gawthrop, “After Ten Years of Index Insurance, What’s Next?” 2018, supra note 244.
288 AgroInsurance, “Columbia – Weather index insurance program for smallholder coffee farms,” (March 10, 2018), available at: https://agroinsurance.com/en/colombia-weather-index-insurance-program-for-smallholder-coffee-farmers/ (last visited August 14, 2019).
289 Souha Ouni, “New Tool Shows Promise For Index Insurance To Reach More Farmers,” 2017, supra note 241.
290 Dan Osgood, “New Climate Data Transforms Insurance Projects in Africa,” (April 12, 2017), supra note 242.
291 Souha Ouni, “New Tool Shows Promise For Index Insurance To Reach More Farmers,” 2017, supra note 241.
292 Dan Osgood, “New Climate Data Transforms Insurance Projects in Africa,” (April 12, 2017), supra note 242.
293 GSMA, “mAgri Webinar 18th Oct 2018: Innovations in Mobile IoT & Big Data for climate resilience,” (October. 2018), available at:, https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/10/GSMA-webinar_-Innovations-in-Mobile-IoT-Big-Data-for-Climate-Resilience.pdf (last visited July 3, 2019)
294 Sean Mattson, “App enables smallholder farmers to be community influences and citizen scientists,” CIAT Blog, April 2, 2019, available at: https://blog.ciat.cgiar.org/app-enables-smallholder-farmers-to-be-community-influencers-and-citizen-scientists/ (last visited July 3, 2019).
295 Ibid.
296 Baishali Mukherjee, “World Bank, CropIn Partnership: 20,000 Farmers in MP and Bihar Adopt Climate-Smart Agriculture Practices,” Scrabbl, available at: https://www.scrabbl.com/world-bank-cropin-partnership-20-000-farmers-in-mp-and-bihar-adopt-climate-smart-agriculture-practices (last visited July 3, 2019).
297 International Coffee Organization, “Achieving the Sustainable Development Goals in the Coffee Sector: Background Paper – ICO/ECF Symposium, held at Brussels, on 6 June 2019,” (June 6, 2019), supra note 23.
298 GISTEMP, “GISS Surface Temperature Analysis (GISTEMP),” supra note 107.
299 P. Berrisford, et al., “The ERA-interim archive,” ERA report series, (1) (2009), 1-16.
300 D. N. Karger, et al., “Climatologies at high resolution for the earth’s land surface areas,” Scientific data, (2017), 4, 170122.
301 M. Nerlove, “The dynamics of supply: retrospect and prospect,” American journal of agricultural economics (1979), 61(5), 874-888.
302 M. J. Roberts, and W. Schlenker, “Identifying supply and demand elasticities of agricultural commodities: Implications for the US ethanol mandate,” American Economic Review (2013), 103(6), 2265-95.
303 Caravela Coffee, “This Is How Much It Costs to Produce Coffee Across Latin America” (2018), supra note 304.
304 International Coffee Organization, “Assessing the economic sustainability of coffee growing,” (2016), available at: http://www.ico.org/documents/cy2015-16/icc-117-6e-economic-sustainability.pdf.
305 Christophe Montagnon, “Coffee Production Costs and Farm Profitability: strategic literature review,” (2017).
306 Caravela Coffee, “This Is How Much It Costs to Produce Coffee Across Latin America” (2018), supra note 304.
307 USAID Bureau for Food Security, “Renovation & Rehabilitation for Resilient Coffee Farms: A Guidebook for

Roasters, Traders and Supply Chain Partners," (2017).
308 International Coffee Organization, "Assessing the economic sustainability of coffee growing," (2016), supra note 305.
309 Ibid.
310 Caravela Coffee, "This Is How Much It Costs to Produce Coffee Across Latin America" (2018), supra note 304.
311 Ibid.
312 Christophe Montagnon, "Coffee Production Costs and Farm Profitability: strategic literature review" (2017), supra note 306.
313 Ibid.
314 Ibid.
315 Ibid.
316 Global Agricultural Information Network, "Coffee international prices do not cover costs for small and medium size farmers," (2018), available at: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Coffee%20Annual_Guatemala%20City_Guatemala_5-9-2018.pdf
317 Caravela Coffee, "This Is How Much It Costs to Produce Coffee Across Latin America" (2018), supra note 304.
318 International Coffee Organization, "Assessing the economic sustainability of coffee growing", (2016), supra note 305.
319 Caravela Coffee, "This Is How Much It Costs to Produce Coffee Across Latin America" (2018), supra note 304.
320 International Coffee Organization, "Assessing the economic sustainability of coffee growing", (2016), supra note 305.
321 IDH and True Price, "The True Price of Coffee from Vietnam," (2016) available at: https://trueprice.org/wp-content/uploads/2016/04/TP-Coffee.pdf
322 R. F. Daly, "Coffee consumption and prices in the United States," Agricultural Economics Research (1958), 10(1489-2016-125250), 61-71.
323 D. Durevall, "Demand for coffee in Sweden: The role of prices, preferences and market power," Food Policy, (2007), 32(5-6), 566-584.
324 Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B., "Chapman and Hall/ CRC," Bayesian data analysis, (2013).
325 IMF, World economic outlook database, (2019), available at: https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/index.aspx.

Funding for this report was provided by:

Federación Nacional de Cafeteros de Colombia

ACRAM
Agence des Cafés Robusta d'Afrique et de Madagascar

AFCA
AFRICAN FINE COFFEES ASSOCIATION

IDB
Inter-American Development Bank

SAGARPA
SECRETARÍA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN
ESTADOS UNIDOS MEXICANOS

PROMECAFE
Por el Desarrollo de la Caficultura Regional

INTERNATIONAL COFFEE ORGANIZATION

Columbia Center
on Sustainable Investment
A JOINT CENTER OF COLUMBIA LAW SCHOOL
AND THE EARTH INSTITUTE, COLUMBIA UNIVERSITY

Suggested Citation

Jeffrey Sachs, Kaitlin Y. Cordes, James Rising, Perrine Toledano, and Nicolas Maennling, "Ensuring Economic Viability and Sustainability of Coffee Production," Columbia Center on Sustainable Investment (October 2019).

Design by Michael Morgan.
Cover photo by Pablo Merchán Montes on Unsplash.
Back photo by Austin Park on Unsplash.

ccsi.columbia.edu

Columbia Center on Sustainable Investment

Jerome Greene Hall
435 West 116th Street
New York, NY 10027
Phone: +1 (212) 854-1830
Fax: +1 (212) 854-7946